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MAGAZINE OF THE NEW YORK ZOOLOGICAL SOCIETY VOL. LXXII NO. 1 FEBRUARY, 1969

ABOUT THE COVER

Front: Muskellunge *(Esox masquinongy immaculatus)*. Poised in the crystal-clear water of a Wisconsin lake, a big muskie waits for its prey. This fierce predator shares its native waters with a host of other fish, including gar, bass, walleye, pike, and trout. Its home lake is actually a fascinating and unusual aquarium exhibit at the Milwaukee Zoo. Alicia Armstrong, a reporter from the *Milwaukee Journal*, describes Lake Wisconsin on page 2.

Back: Mandrill *(Mandrillus sphinx)* of West Africa. The brightly colored face of the male makes this species the most spectacular of the baboons.

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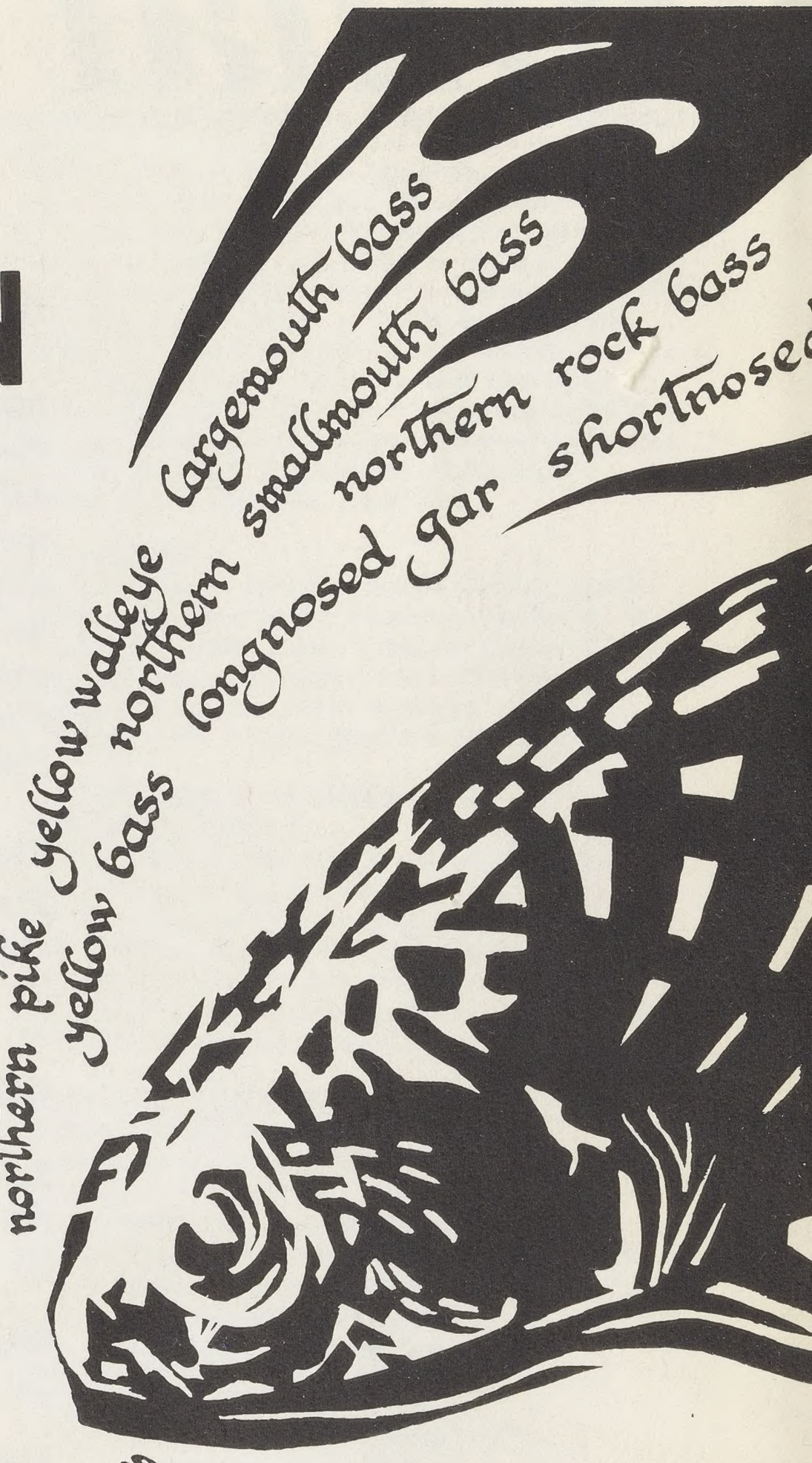
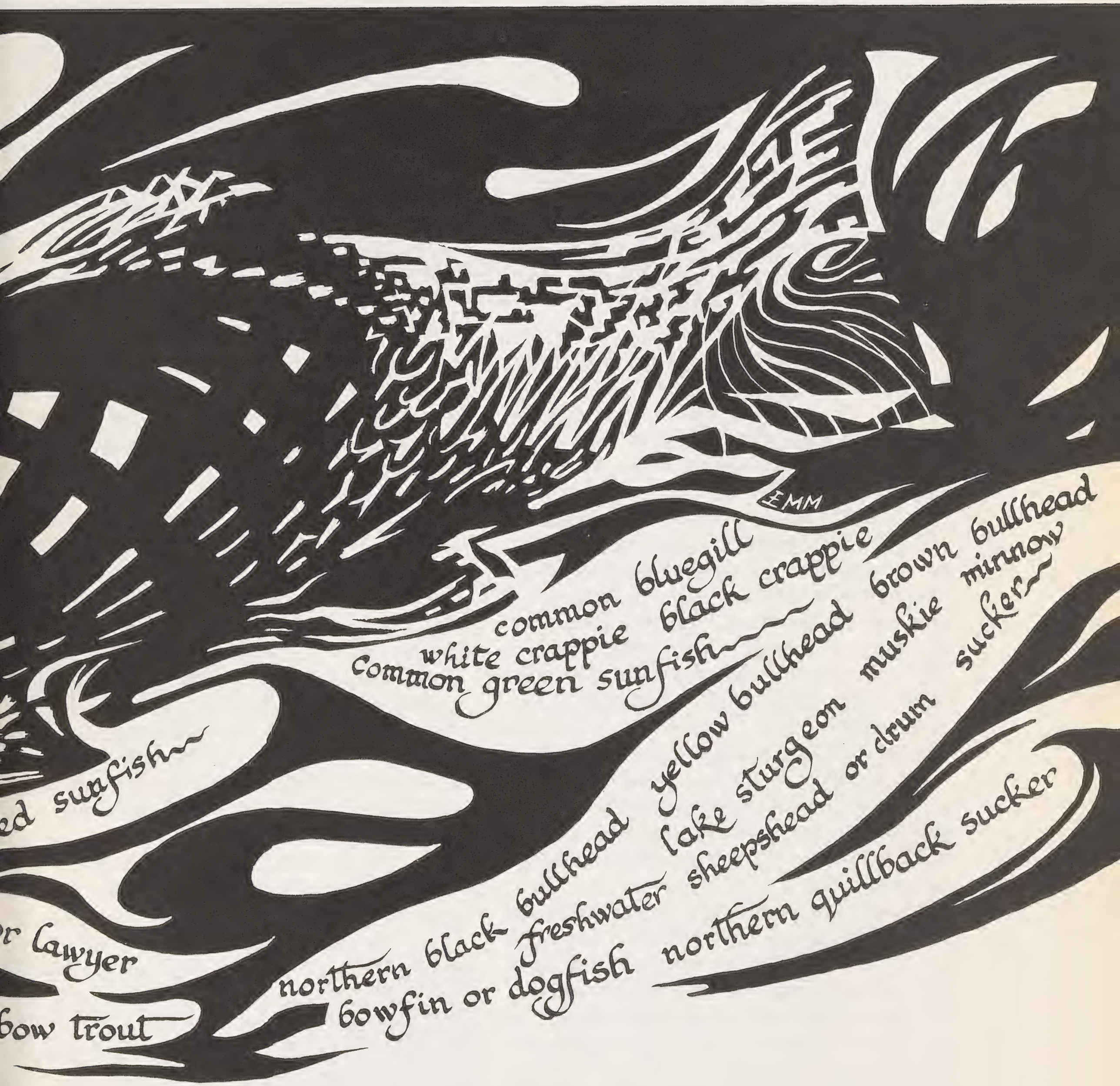
LAKE WISCONSIN



AN UNDERWATER WORLD AT THE MILWAUKEE ZOO

BY ALICIA ARMSTRONG



That sleek muskie cutting through the water doesn't know it but it is part of a complicated, delicate balancing act. ■ The muskellunge, as it is formally known, is one of the inhabitants of "Lake Wisconsin," the big tank in the center of the Milwaukee County Zoo's new million dollar aquarium and reptile house. ■ Lake Wisconsin is an exhibit of fish found in Wisconsin waters; its denizens include northern pike, various bass and gar, lake sturgeons, rainbow trout, and many other species. ■ Later other kinds of fish will be introduced into the lake. Plans are to exhibit at least 40 species. But the present cast of characters shows the need, recognized in the earliest planning stages, that several kinds of balance must be maintained. Temperature is one factor. Trout, for instance, like cooler water than carp and panfish do.

The proper relationships must be maintained between prey, predators, and scavengers. The dissolved oxygen in the water is kept at a high concentration for the adequate consumption of all the fish, and the water chemistry must be of such composition that the diverse fish will find it agreeable.

Simulated granite formations in the middle of the 45,000-gallon tank provide crevices, undercuts, nooks, and crannies, so that smaller fish can find places to hide or at least get out of the path of the big ones.

Kenneth C. Schoenrock, the aquarium supervisor, pointed out that minnows, perch, and other moving meals would get very nervous if they could not get away from the voracious muskies, pike, and bass. Lighting was planned so that nooks are shadowy and, therefore, relatively safe.

Opportunities for escape and concealment are essential for the well-being of the fish and the over-all balance of the lake.

Plants on the lake bottom are arranged to provide retirement areas for fish, but they are not so thick that they hide the fish from the view of visitors.

Permanent balance, however, is never achieved. The water is constantly checked, because adjustments must be made whenever the environment changes, even slightly. Environment changes occur when new fish are added, when the ratio of prey, predator, and scavenger varies significantly, or when new species are introduced. Some 40 or 50 pounds of minnows are dropped in about once every two weeks.

George Speidel, the Milwaukee Zoo director, hoped the tank would interest fishermen (Wisconsin is one of the country's foremost fishing states) and instruct those people who know little or nothing about fish. Both goals clearly have been achieved.

Fishermen sometimes seem hypnotized by the lake, gazing into it for hours. They see things they've never seen before—the wicked, gleaming teeth of the muskie as it prowls, the flight of minnows when a black bass slashes into their midst, the wanderings of the curious, colorful pumpkinseeds.

Visitors who watch through the viewing ports of this artificial body of water see a close-up of life in the lake. The sturgeon cruises along the bottom, snatching up scraps with a mouth that has been likened to a plumbing plunger. Sociable bluegills swim about together. The pike hunts alone.

Muskies in Lake Wisconsin are tiger, or northern, muskies, a subspecies of the typical muskie. The "tiger of the north" has dark olive-mottled stripes which run vertically across its silvery-bronze body.

Muskellunge, "the tiger of the north."

The muskie is the glamor fish of the north—the ferocious hunter, the brute, the fighter of fishermen, the fish of mystery. And an estimated 150,000 to 160,000 of the approximately half-million people who fish in Wisconsin each year concentrate on the muskie.

It is a fish that obsesses its pursuer. One newspaper writer described a muskieman's reaction to the muskie this way: "What other fish can turn a man's legs to rubber, his insides to an icy mass of gnawing pain, simply by following a lure to boatside? What other fish can turn a man's mind to reeling, cause his heart to hammer, his eyesight to dim, by floating in behind a bait and staring upward for an instant with baleful, accusing eyes at the one who would cause its death?"

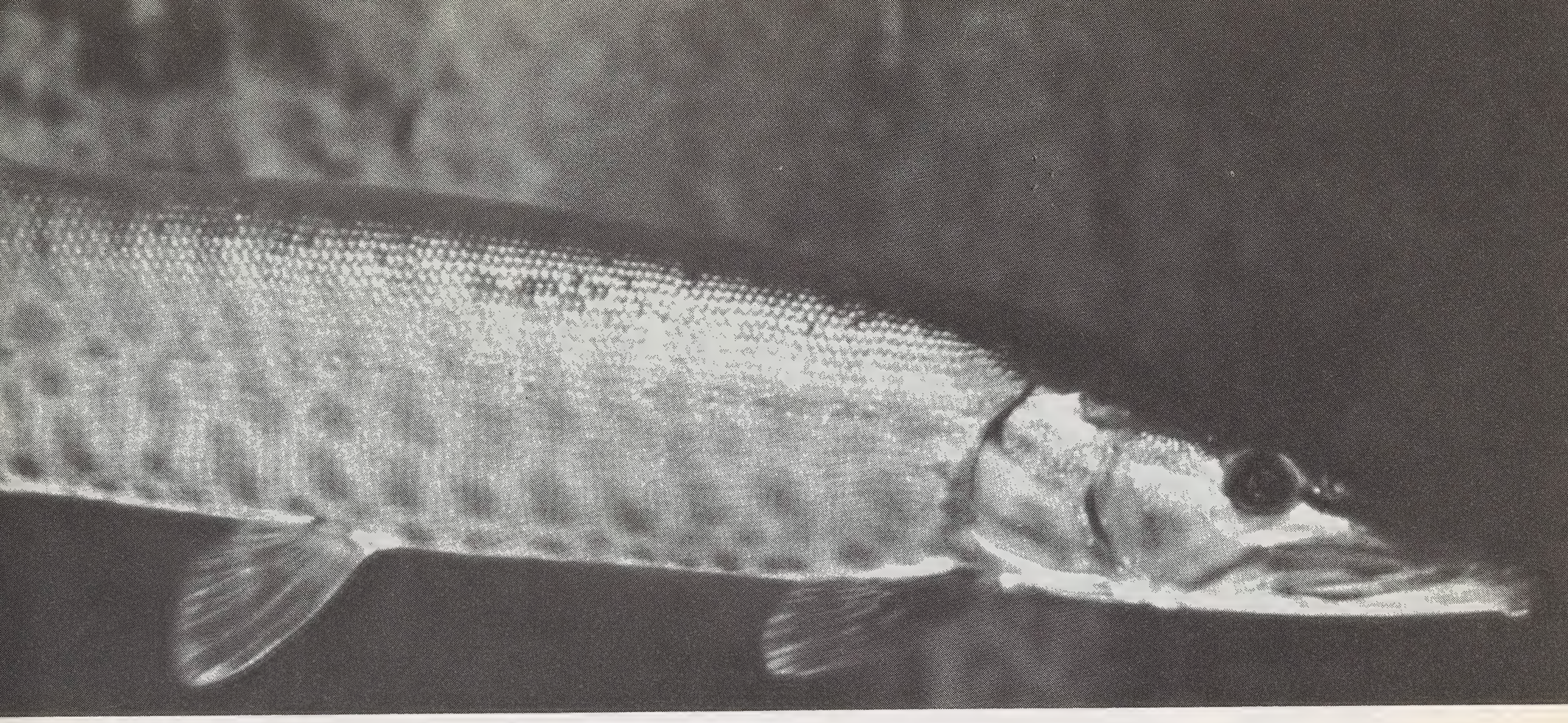
Another breed of fisherman says the muskie has only the reputation—that pound for pound, the bass is the gamest fish that swims.

Mr. Schoenrock says, however, that the toughest fish in the tank now is the bowfin. "It goes where it wants to go," remarks Mr. Schoenrock, "and other fish, including the muskies, get out of its way."

However, eventually the muskies will be much larger than the bowfins, so that even the most aggressive bowfin will be forced to give ground or in the most unfortunate circumstances, find that a muskie has selected it as a mid-day snack.

The world record muskie, caught in 1957 in New York's St. Lawrence River, weighed 69 pounds, 15 ounces, topping the previous record fish—which had been taken in Wisconsin—by 3 ounces.

So eventually, when mature, muskies will be the biggest predators in the tank by a wide margin. Lake sturgeons grow biggest—the state record is 180 pounds, but the sturgeon is not a predator. It is a scavenger. And sturgeons grow slowly—more



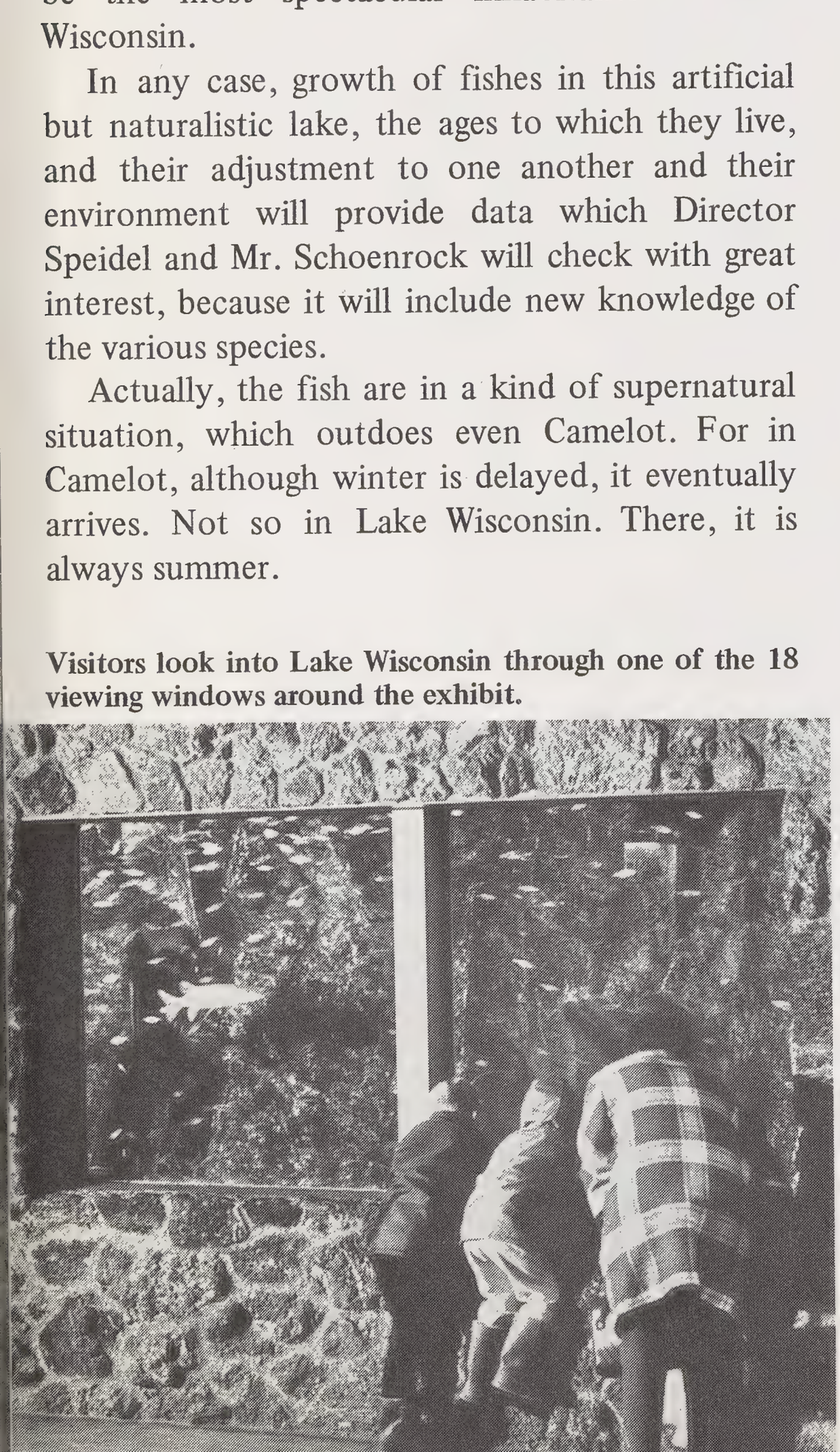
slowly than some trees. A 40-inch sturgeon, which is the minimum legal size in Wisconsin, would be about 13 years old.

Mr. Schoenrock says there is reason to believe, at this time, that the lake might well produce several record-size muskies which would, of course, be the most spectacular inhabitants of Lake Wisconsin.

In any case, growth of fishes in this artificial but naturalistic lake, the ages to which they live, and their adjustment to one another and their environment will provide data which Director Speidel and Mr. Schoenrock will check with great interest, because it will include new knowledge of the various species.

Actually, the fish are in a kind of supernatural situation, which outdoes even Camelot. For in Camelot, although winter is delayed, it eventually arrives. Not so in Lake Wisconsin. There, it is always summer.

Visitors look into Lake Wisconsin through one of the 18 viewing windows around the exhibit.



The water is kept between about 65 and 70 degrees year-round, and 12 sunlamps above the water stimulate production of vitamin D in the fish. Ultraviolet rays from 4 Gro-Lux bulbs, which cast an eerie bluish glow, stimulate plant growth, and 18 floodlights of the kind used in swimming pools shine under water.

In this lake of perpetual summer, fish are more active and grow faster, Mr. Schoenrock says, adding: "We expect to grow some monsters here."

In six months, muskies have about tripled in size, and northern pikes have doubled. Even the common bluegills are the size of small bass.

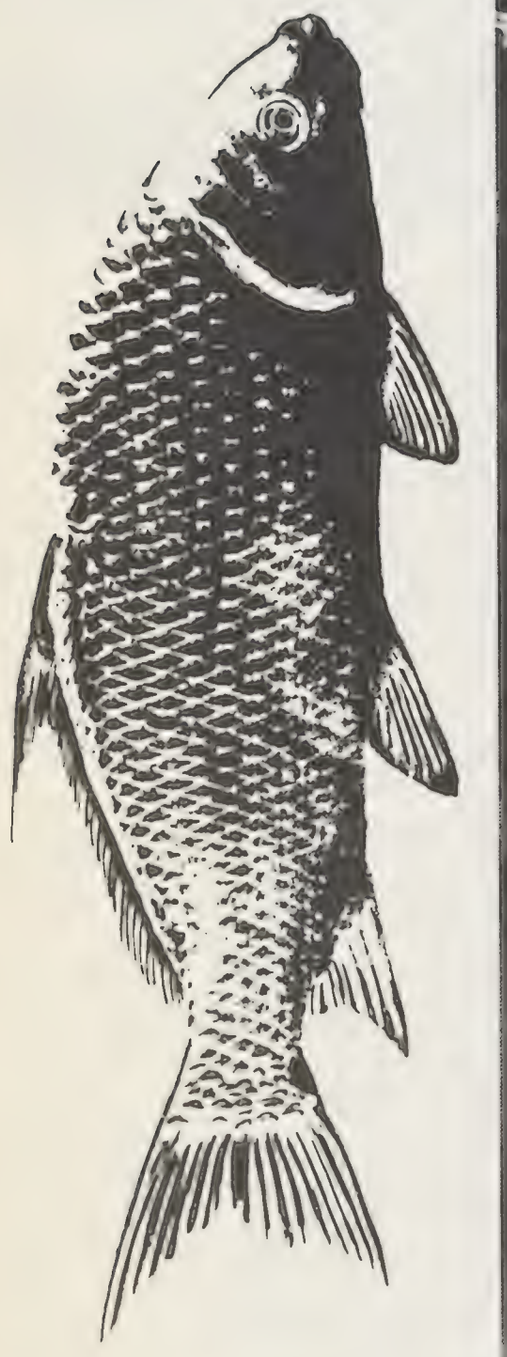
According to Mr. Schoenrock, many people mistakenly thought that fish of the north needed to be in ice cold water to do well. And, he adds, there are other environmental conditions which occur in the wild but which fish could do without, just as most Wisconsin residents could do without 30-degree-below-zero weather.

For instance, bottom feeders such as sturgeon, bullheads, sheepshead, and suckers ordinarily would poke around in mud. However, there is no mud in Lake Wisconsin, and the fish give no indication of pining for it.

Plants which take root in soil do not grow in the Milwaukee Zoo's lake. Soil would mean mud, and mud would obscure drastically the visitors' view. So the hornwort plant, which, in the wild, grows on the surface or slightly below the surface, is used. Weights are tied to the center of bunches of this plant, so that it looks as if it is rooted on the lake bottom.

A constant stream of air is blown across the outside of the viewing windows to prevent condensation and insure good visibility.

Lake Wisconsin is 15 feet wide, but it seems wider when one looks through the crevices and sees the silver bodies drifting through golden light.



Aquarium supervisor, Kenneth C. Schoenrock (at right), wearing scuba gear, conducts an underwater inspection of the lake's rock-work and window seals. Among the inhabitants under his charge are (above, from top to bottom): a dogfish, or bowfin; a muskie and golden shiners; a black bullhead; and a northern quillback carpsucker.

Many fish, seeking detours or relative solitude, glide through the tunnel crevices.

Most of the fish in this lake were provided by the state's Department of Natural Resources. And all of the species are plentiful in Wisconsin waters.

Fishing was important in Wisconsin long before the advent of the white man, for fish were a chief food of Indians—the Chippewas, Winnebagos, Potawatomis, and others. In winter, fishing was an arduous occupation for Wisconsin's first inhabitants. Indians cut holes in lake ice, and with only blankets covering them in sub-zero weather, they lay on the ice to watch for sturgeon and spear them.

Winter sturgeon spear fishing now is an indoor sport. Men wait in small, heated shanties for the big, dark shadows to glide through the frigid water under the ice holes. These fishermen use spears with three or four tines honed needle-sharp. Sometimes a wooden fish decoy is used or a rubbing post is sunk in the water, for sturgeons like to scratch their leathery hides.

At one time sturgeon were simply destroyed as nusiances when they were found in fishermen's nets. However, their rich flesh now is a gourmet's delight, and their eggs, when salted and pressed, become caviar. The sturgeon is the subject of intensive research in primary Wisconsin waters, and the fish is protected from poachers.

Wisconsin also has been a leader in the development of muskie management techniques. And now, this state has the country's foremost program of muskie reproduction and stocking.

Minnows, which are fed horseheart and prepared dry foods, are food for other fish in Lake Wisconsin, as they are in the wild. Some of the more common minnows in the artificial lake include golden shinners, fathead minnows, lake shinners, river chubs, redbelly dace, and pearl dace. The fish food group also includes common white suckers and redhorse suckers.

However, as Mr. Speidel anticipated, the minnows also have become favorite display fish as they cruise, silvery and bright, in large schools.

Display fish also sometimes abruptly end their careers by becoming food fish. The muskies have developed a taste for rainbow trout, which proves that they are discerning as well as fearsome.

Lake Wisconsin is the dominant feature of Milwaukee's combination aquarium and reptile house. The lake is 68 feet long, with 164 feet of viewing area. Visitors, who walk around the entire exhibit, view the fish through 18 large windows. The glass is two-and-one-quarter inches thick to withstand water pressure.

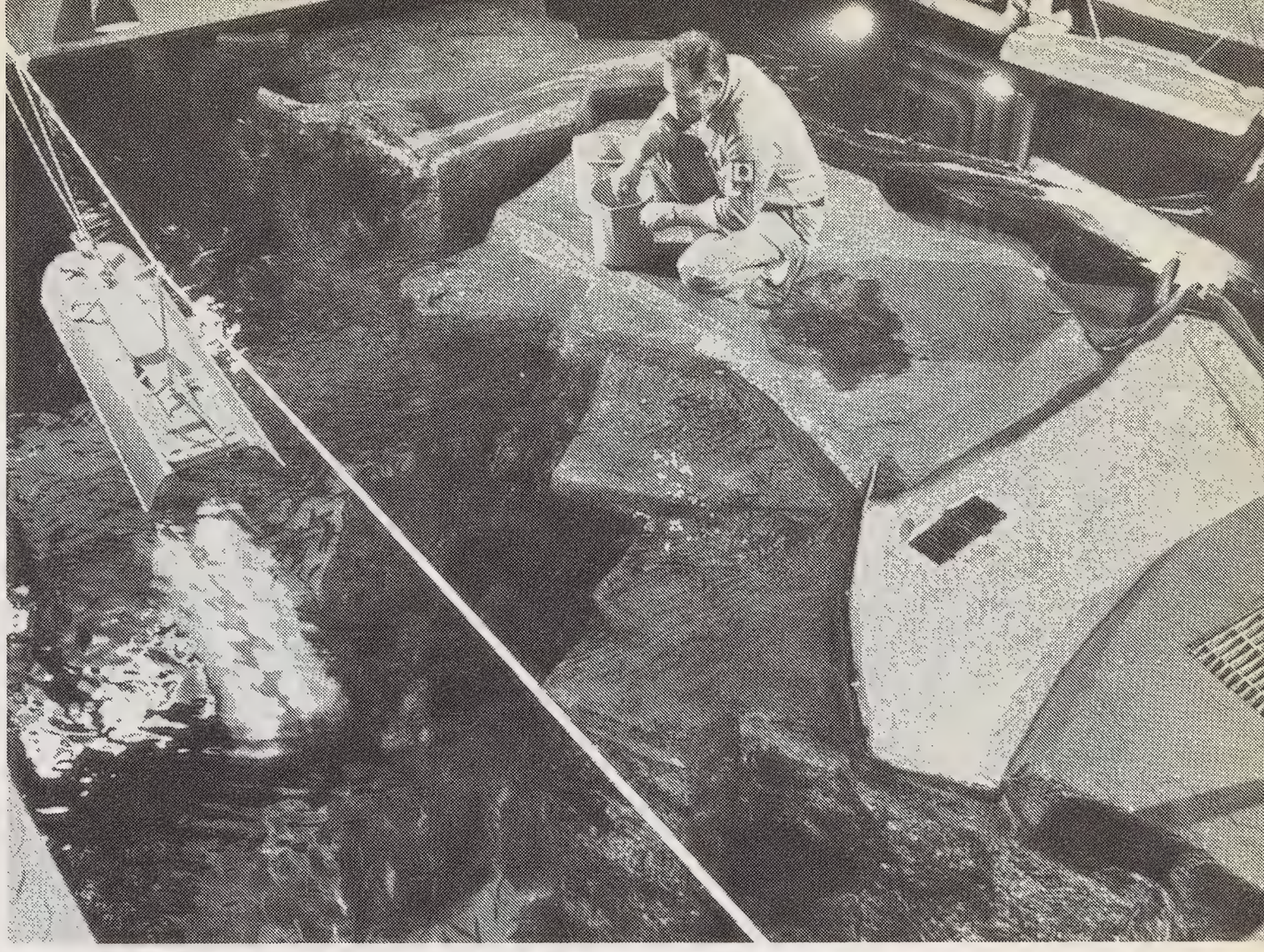
The water is as clear as a fresh mountain stream, because of the building's efficient filtering system. A separate sand and gravel filter services

Among the many denizens of Lake Wisconsin are a longnosed gar and shortnosed gar (shown above) and a soft-shelled turtle (below).

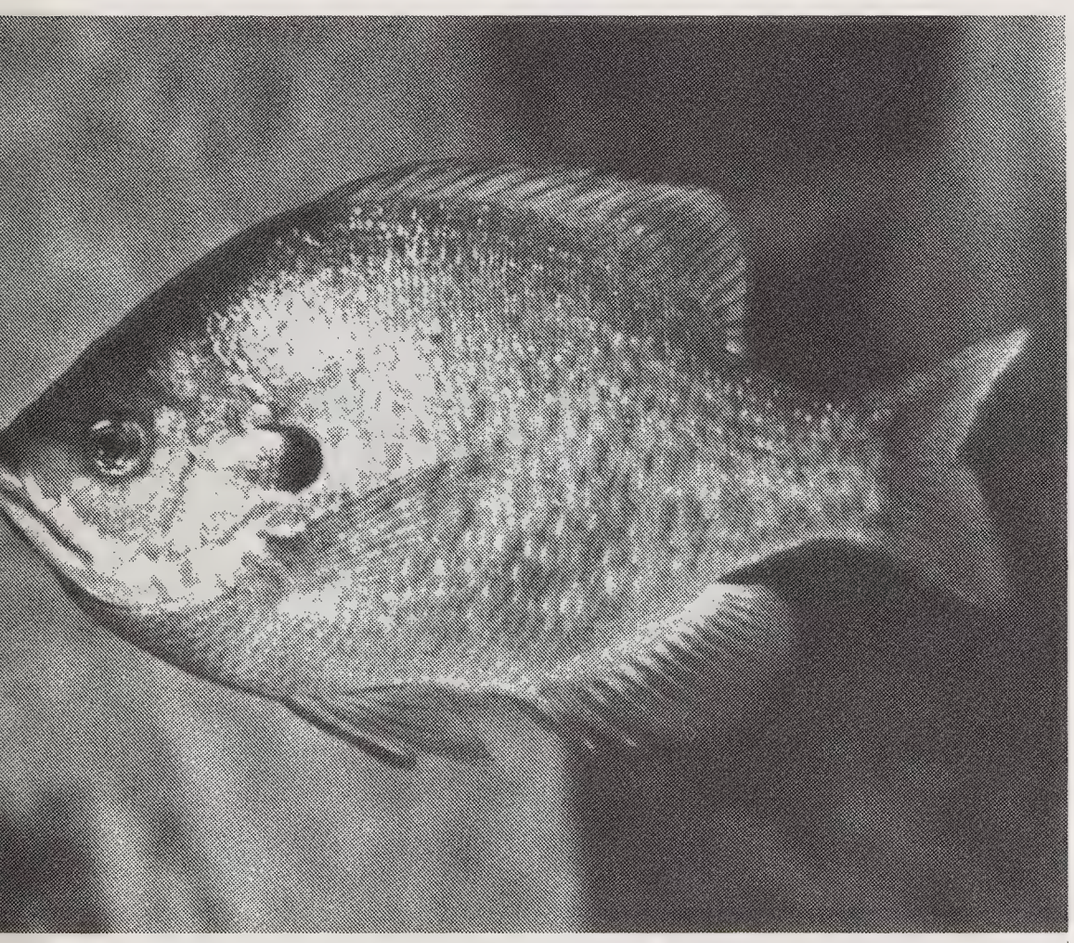
the lake at the rate of from 500 to 600 gallons per minute—as other separate filters service an Amazon river display and a freshwater dolphin tank. The Amazon river display is filtered at a much lower rate than the other two—from about 40 to 45 gallons per minute.

One diatomaceous earth filter serves as a community filter. Under normal conditions, the community (D-E) filter is used in conjunction with one of the three sand and gravel filters, and if a disease should break out in Lake Wisconsin, the Amazon river display, or the dolphin tank, the D-E filter could be set up quickly to filter water in the effected tank separately and thereby eliminate additional bacteria.

A 65,000-gallon holding reserve tank is directly below Lake Wisconsin. (The exhibit tank itself is a 65,000 gallon area, but the rockwork displaces about 20,000 gallons.) A small amount of reservoir water is also added every day to the lake display tank and an equal amount of water is drained from the lake. This constitutes a system enabling Mr. Schoenrock to maintain a continuous diversion of harmful gases that otherwise would build up in the closed system. In hot weather, when the lake temperature goes above 70 degrees F., more of the cooler water is continuously added to bring the temperature down and hold it down.



The service area of the lake is on the second floor level, out of public view.



A bluegill is another of the fish on display in Lake Wisconsin; eventually some 40 species will be exhibited.

Before water from the city water system enters the reservoir tank, it passes through activated carbon filters that remove chlorine. Water entering the reservoir from the carbon filters is heated to 65 degrees F. From the reservoir, it is heated an additional 10 to 15 degrees for the dolphin display. The water also is heated an additional 15 degrees—to 80—for the Amazon river exhibit.

Lake Wisconsin, which is about nine feet deep, is serviced from the second floor level, out of the public view. Wearing scuba gear, Mr. Schoenrock and keepers regularly drop into the water to perform various functions, such as inspecting the tank and cleaning it.

Sanitation is of critical importance in preventing disease. Also, new fish are checked carefully, and many, including new species, are quarantined as a precautionary measure before they are introduced into the lake. Medication is added to the quarantine water when needed, and plants are rinsed and dipped in disinfectant.

The balancing act began at the beginning—when the first fish were introduced into the tank. Almost any big fish will eat smaller fish, even a close relative, so minnows, sunfish, and other smaller species were placed in the tank before big predators—giving potential prey an edge by getting used to the tank and its hiding places. Also, Mr. Schoenrock saw to it that the muskies were nearly the same size as the northern pike and other fish so that they would not immediately consume them. On the other hand, the northerns could not be too big or they might promptly eat the muskies.

Fish stake out territories in the lake, but they are not really possessive about them.

"In the wild, territories are set up to obtain an adequate food supply and for concealment," Mr. Schoenrock says. "But there is more than enough food in our lake, and in this relatively small area, fish get rather used to one another."

Are they used to the lake? Is it a good home away from home?

The answer to both questions obviously is "yes." The fish are active, growing rapidly, and although northern freshwater fish usually are not thought of as being brightly colored, the colors of Lake Wisconsin dwellers are as vibrant as they are in the wild.

These fish are in captivity, true, but they also are free in a place where the feeding is easy and where summer will never end.

MONKEYS OF THE SNOWY FOREST

BY CARL B. KOFORD

If you walk through a beech, oak, and maple forest and see high on a branch a large, brown, furry ball, you may not be in New York looking at a raccoon but in northern Japan looking at a monkey. The Japanese monkey *(Macaca fuscata)* occurs farther north than any other primate except man and lives in hardwood forests much like those of our northern states. South and west of Tokyo the monkeys are found in broadleaved evergreen forests where it rarely snows. But in the north, most leaves disappear in winter, snow blankets the ground for months, and temperatures fall near zero. How do monkeys, which evolved in tropical and subtropical climates, get along under such rigorous conditions? During the course of a comparative study of birth seasons, I had an opportunity to find out.

The northernmost study troop was located on the rugged west coast of Shimokita Peninsula at latitude 41° 07' N near the roadless fishing village of Kusodomari. Commencing in 1965, the monkeys were somewhat tamed by feeding them soy beans, peanuts, sweet potatoes, and other choice foods in a forest clearing. Then Shigeru Azuma of the Japan Monkey Center started observations, and on occasions during the next year I worked with him. From years of experience with an island monkey colony in Puerto Rico, I was well acquainted with the common rhesus monkey *(Macaca mulatta),* a native of India. In contrast to that species, the Japanese monkey is physically adapted to a colder climate—its tail is much shorter, body slightly larger, and hair longer. At Kusodomari, the fur was so long and erect that, with their stubby tails, the monkeys resembled fuzzy bear cubs. I found the behavior of Japanese and rhesus monkeys to be similar, though the former are less agile in trees.

The Kusodomari troop ranged over several deep wooded valleys that drained westward from a high wooded ridge to the rough rocky shore. The valleys not only provided protection from fierce winds but the trees and steep slopes broke up the snow surface. Rock outcrops also penetrated the snow and, being dark, absorbed snow-melting heat and exposed platforms where monkeys often sat to groom each other or bask. Even during heavy snows, ocean tides exposed seaweed, limpets, flotsam, and other occasional foods along the shore. Though leafless in winter, stout branches of beech *(Castanea crenata),* oak *(Quercus mongolica),* maple *(Acer mono),* and other hardwoods provided steady perches for resting and sleeping as well as some weather protection. The only big evergreen, a cypress *(Thujopsis dolobrata)* valued for building temples, offered even better shelter. To avoid the rigors of climate, the monkeys had chosen their habitat well.

In behavior, too, they adjusted to the snow and cold. At times a monkey in a tree avoided descent to the snow by tightrope-walking far out on an arching whippy branch and stretching across to another. When the troop crossed a wide snow patch, the members usually walked slowly in single file, a large male breaking trail. Among obstacles, however, they walked more independently. On very cold or stormy days the animals remained crouched, heads down, into furry balls among the branches. Often two huddled together, or a mother huddled with her infant and two or three juveniles. At another cold locality, Akira Suzuki of Kyoto University once saw 15 lumped together.

In warmer parts of Japan, many troops have more than one hundred members, whereas in the north the known troops are rarely half as large. Possibly the small number is a result of hunting in former times, but more likely it is an evolutionary adaptation to prevent excessive use of the restricted winter food supply.

In 1965 the Kusodomari troop had only 20 members, including five infants, seven juveniles from one to five years old, six adult females, and two adult males.

As usual in macaque groups, the older male was the leader, a placid animal who settled squabbles among the females and subtly controlled movements of the troop. The other big male was his subordinate and moved away or cringed slightly, baring his closed teeth, when the leader approached. But if a human drew near, it was the subordinate who charged him, growling, long canines bared. Doubtless alien monkeys got the same hostile reception.

An adolescent male about five years old played with other juveniles and followed his mother, but had little contact with the older males. Among adult females differences in social rank were slight, but the oldest, somewhat decrepit, gave way at the food supply to two more vigorous females, and two adolescents gave way to all adults.

During this study, Dr. Koford was a Visiting Scientist, Delta Regional Primate Research Center, Tulane University. He was supported by National Institutes of Health Grant FR-00164 and by National Science Foundation Grant GF-205.

As in most macaques, the first indication of physiological changes leading to mating was a reddening of the naked skin of face and thighs. Adult males started to flush in late summer, but it was several weeks later before females flushed and started to seek male company. Starting in late October, over a period of three months, the females became pregnant.

At other localities they usually conceive first at four years of age and bear an infant nearly every year until more than 20 years old, the physical equivalent of about 70 years in man. Inasmuch as gestation requires about 24 weeks, young were born in spring. Of eight births in the troop over a period of two years, the earliest occurred in mid-April and the latest in mid-July. These were the first birth dates known for a troop north of 37^{o} latitude, and we were surprised that births started so early.

In most animals, birth seasons become later with increasing distance from the equator, but this northern season was about the same as in monkey troops near Kyoto, six degrees to the south. When the first young appeared at Kusodomari, a few patches of snow remained, temperatures occasionally fell near freezing, and tree buds were dormant.

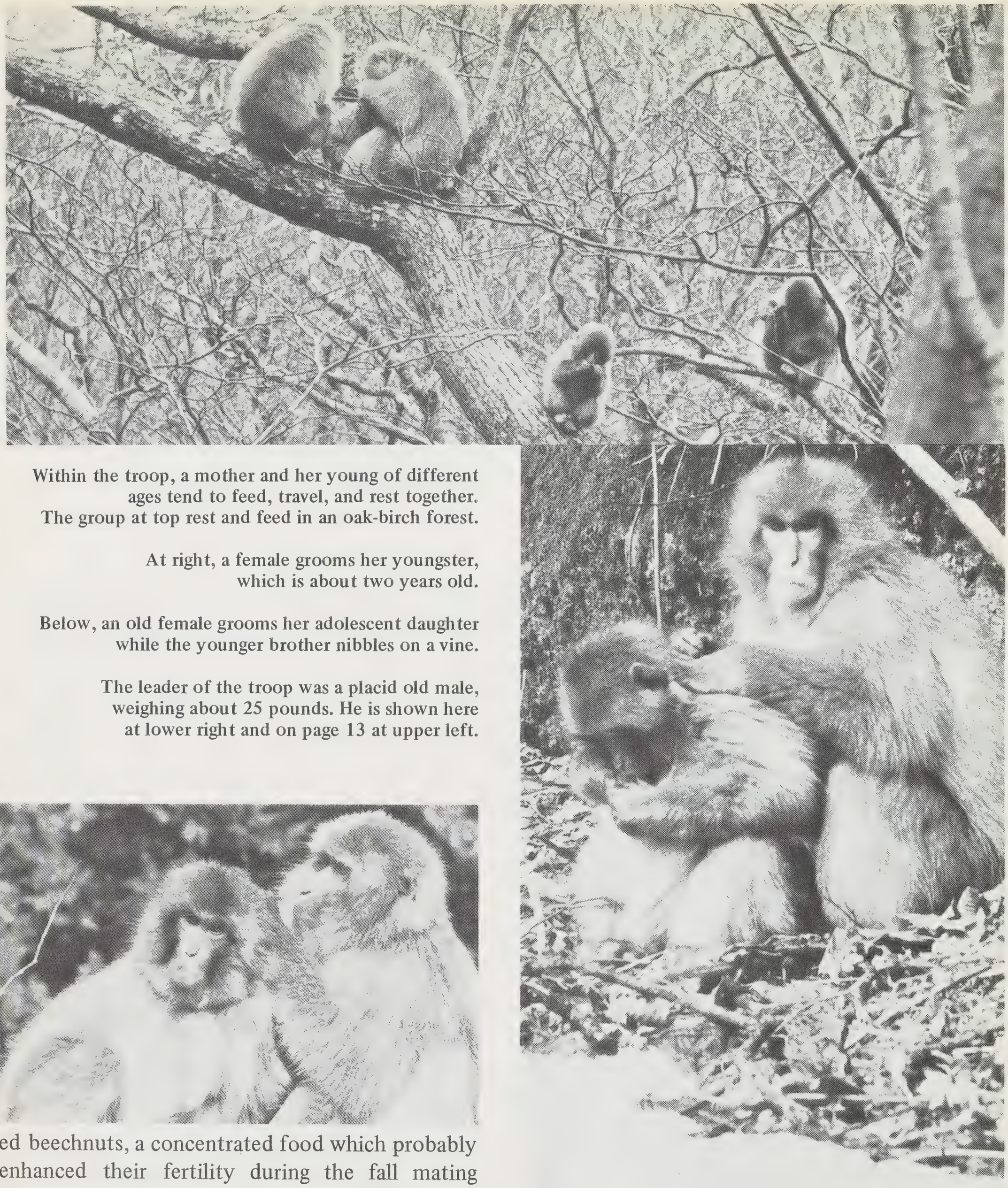
Inasmuch as birth seasons evolve to insure the best survival of groups under average conditions, there must be some advantage to a comparatively early season in the north. It may be that early births insure maximal infant development and maternal independence before the ordeal of winter. Before late May, when half the infants had arrived, tree buds burst, herbs sprang up, and some trees flowered, providing abundant nourishment for the new mothers, their suckling infants, and weaned yearlings.

In winter the chief foods were the buds and bark of beech, maple, oak, elm, ash, and other woody plants. From some branches the monkeys cleaned the bark in rows of scalloped bites, and from others they bit and pulled off long bark strips in order to eat the underlying white layers. At times they concentrated on winter buds, stripping all within reach. Again they gnawed cypress twigs or nibbled sedge clumps protruding from the snow, and occasionally they foraged along the seashore.

When spring broke the monkeys sought new leaves as they appeared, then willow catkins and other early flowers, and later they relished blossoms of wild cherries and plums. As leaves toughened in summer they diminished in the monkey diet while grapes, berries, seeds, and nuts increased. Starting in September the animals favor-

An old female monkey eats twigs on a *Thujopsis* stump while her yearling basks alongside.

Their large size, short tail, and long fur enable these animals to resist cold (above, at left). When trees are leafless, the monkeys eat bark or winter buds (above, right). As the snow melts, they often forage, rest, and groom on the forest floor (below).



Within the troop, a mother and her young of different ages tend to feed, travel, and rest together. The group at top rest and feed in an oak-birch forest.

At right, a female grooms her youngster, which is about two years old.

Below, an old female grooms her adolescent daughter while the younger brother nibbles on a vine.

The leader of the troop was a placid old male, weighing about 25 pounds. He is shown here at lower right and on page 13 at upper left.

ed beechnuts, a concentrated food which probably enhanced their fertility during the fall mating season, and by the end of the year they returned to eating little but bark and buds.

As for most wild mammals, it is not yet clear how nutrition, falling temperature, decreasing day-length, or other ecologic conditions govern the onset of mating and keep the annual reproductive cycle in appropriate step with season environmental changes, but comparisons among Japanese monkey troops are starting to illuminate these relations. There are a few hundred known monkey troops in Japan, as far south as subtropical Yakushima (30.5° N), and under protection the numbers are increasing. About 25 troops are fed in monkey parks, where visitors can study them. In some regions amateur monkey-watchers are as common as bird-watchers in the United States.

DRAWINGS BY EDWIN GAMBLE

The shapes I first came to know well were the hulls and sails of boats of the coast of Maine and the wings of gulls in flight. While still young, I went west and lived amid the pared-down sculpture of the New Mexico landscape. Early in my art training, I learned to use, as a tool for drawing, a sharpened stick dipped in India ink. I am acutely aware that this early knowledge, these early experiences show now in my work. As an abstractor, I reduce and eliminate, knowing that the danger of trying to say things too simply is that they may be said boringly. To avoid – to try to avoid – this, I make constant reference to nature, observing and making notes in drawings, then putting the drawings away and relying on what they taught me. I study birds intensively – mostly shore birds, partly because of their shapes and poses, partly because they stay in one place long enough to make study simpler. Birds have been part of my world since I was a boy. I write about them, lecture to children about them, take great delight in them. But in my works birds are only a vehicle, no more than that – yet an ever absorbing stimulus and inspiration.

SHORE SHAPES

RUFF

AFRICAN JACANA

SCARLET IBIS

WOOD SANDPIPER

EGYPTIAN PLOVER

BLACK-NECKED STILT

THE PARROTS OF BUSH BUSH

BY FERNANDO AND MARTA NOTTEBOHM

On Trinidad's eastern shore, sheltered from the Atlantic surf by a long sand bar, lies the Nariva Swamp, a unique sanctuary for wildlife of many kinds. Flood waters from torrential rains render its dense stands of aquatic vegetation and swamp forest virtually impassable during most of the year. As a result, it has remained a domain not of man, but of nature. There, surrounded by a sea of grasses and palm groves waist-deep in water, stands Bush Bush Island. It was our home for five months, from January to June 1968, during the first phase of a long-term study of the natural behavior of the orange-winged amazon parrot, *Amazona amazonica.*

Quarreling in the tree tops or pirouetting in mid-air, loud and alert, parrots are among the liveliest sights in Trinidad. To the biologist, in addition to their esthetic charm they pose questions of considerable interest.

Why are birds, next to man, the best vocal imitators of the animal world? Humans can learn to reproduce any of a great variety of sounds and use them for purposes of communication. But no other primate—or mammal for that matter—is known to share this talent. A few passerine birds, such as the Indian hill mynah and the Australian lyrebird, have a just reputation as mimics. But in one particular avian family, that of parrots (Psittacidae), the ability to imitate sounds seems to have reached its peak.

Surprisingly, most of our knowledge about members of this group originates from folklore and from people's experiences with captive pets. Parrots and parakeets, macaws, budgerigars, and even cockatoos have been reported to imitate human sounds in captivity. Yet there is a complete lack of information on how these animals use their imitative powers in the wild. A study of the natural behavior and vocalizations of different members of the parrot family may well open unexpected vistas to our understanding of sound imitation in animals. With this hope in mind, we started our project in Bush Bush.

Amazon parrots (those of the genus *Amazona)* are broadly distributed over the tropics and subtropics of the New World. They comprise some 30 species characterized by a stocky build, a relatively large head, and short tails. Like most birds in this group, Trinidad's amazons are predominantly green; otherwise they can be recognized by their yellow cheeks and a broad orange band on the tail; their forehead and crown are blue and may include a yellow patch of variable size; the extended wings show a patch of orange, from which the orange-winged amazon parrot derives its name.

In Bush Bush we lived in a cabin lent to us by the Trinidad Regional Virus Laboratory. Tucked away in a small, leafy clearing, it gave us shelter from the weather and protection from the innumerable mosquitoes. The wire screening on its windows and doors kept outside most of the tarantulas, the scorpions, or the centipedes that happened to amble by. Armed with binoculars, from our porch we could explore the fronds of scores of different trees, some of them truly gigantic.

The first sound to wake us up in the morning was usually a male howler monkey, its deep roar resounding in the forest. Invariably, 10 or 15 minutes later the loud cries of parrots started, as they congregated in large groups on the tree tops. These dawn gatherings occured every morning and seemed to be important to these very sociable birds. At that time the forest was a bedlam of buglings and warbles, shrieks and rattlings, which masked all other sounds.

Parrots eat fruits, flowers, and occasionally buds. When feeding they are silent, but their careless table manners give them away, as a constant shower of half-eaten morsels falls to the ground. Often we would see evidence of parrots feeding, but as we raised our eyes to the luxuriant tropical canopy 70 to 100 feet above we could only see leaves.

Parrots are not easy to study in their native habitat. They may seem gaudily colored when perched in a drab cage bare of vegetation, but in the treetops those same birds are virtually invisible. Usually orange-winged amazons are seen high up, flying or foraging in pairs. In the evening the pairs converge on a particular cluster of trees or

Dr. Fernando Nottebohm, shown at left, is principal investigator in a research project sponsored by the National Science Foundation and the New York Zoological Society.

Here, in the Trinidad jungle, the authors study parrots.

bamboos to roost communally, up to more than 600 birds together. During the breeding season, however, attendance at these roosts decreases: then some pairs seek a suitable hole in which to nest.

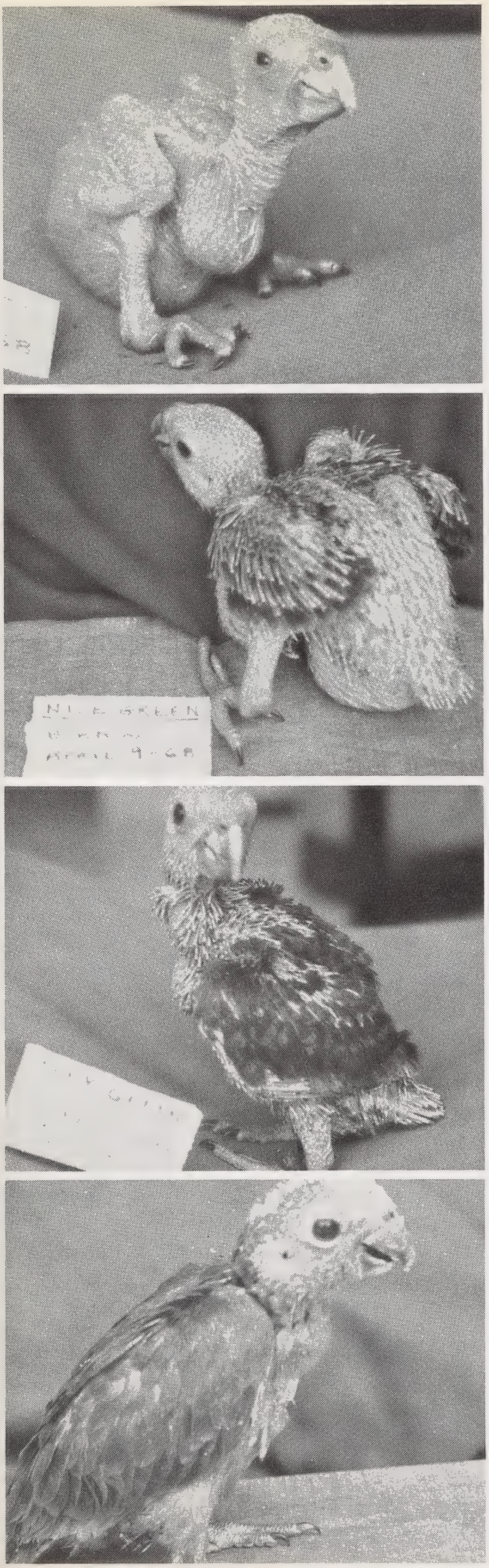
Moriche palms are found in large clusters around Bush Bush and elsewhere in the shallower waters of the swamp. When one of these palms dies and rots inside, amazons nest in the partly hollow trunk. The smaller red-bellied macaws, *Ara manilata,* also vie for ownership of such potential nest sites. Since neither species builds its own nest, they have to wait for suitable opportunities to be provided by nature.

The orange-winged amazons seem to have a well-defined breeding season. During our stay in 1968, most eggs were laid in the month of March; possibly the commencement of breeding is linked to the onset of the dry season. Two to four oval white eggs constitute the usual clutch. Incubation lasts for some three weeks, with only the female sitting on the eggs. She leaves the nest only for short periods of time, when the male comes to feed her. As the cock arrives, the female joins him and they fly together to a nearby treetop. There he feeds his mate by regurgitating food into her beak, just as both adults will later feed the chicks. As the female returns to her clutch, her partner remains vigilant near the nest site or once more departs to forage for food.

After hatching, the young remain in the nest for two months. At dusk, while the hen stays in the nest with her eggs or chicks, the male flies away to spend the night in a communal roost several miles distant.

Observing the private life of parrots called for some premeditation. The procedure became routine. Rising at four o'clock was important. After a quick breakfast, and with the aid of a headlamp, we waded into the swamp. As we negotiated sunken logs and swatted greedy mosquitoes, our main worry was not to wet the equipment —binoculars, lenses, and tape recorder. Eventually we reached our burlap blind, a half-hour trip from the cabin. Soon it was light enough to see the weathered moriche stump where a pair of amazons was nesting. This was one of several pairs we had followed for almost three months. "Spot," the female, would slowly appear at the entrance of her nest, looking ruffled and sleepy. A few minutes

The Nottebohm's home on Bush Bush was built of cement-asbestos planks on a concrete slab.



Stages in the growth of young amazon parrots are shown here. From top to bottom, these birds are two, four, five, and six weeks old.

later "King," her mate, arrived. Any calls produced by either bird were recorded on tape, while we described in a notebook what was going on. With few breaks we continued our observations for several hours, sometimes until sundown.

It is relatively easy—if not very comfortable—to watch parrots around their nest from a blind. But it is much harder to follow them when they are foraging in the treetops. Distance is a problem here; as we looked up from the dappled shade of the forest floor, the parrots, when finally spotted high above, were in another world. To meet this problem we built an observation post 70 feet from the ground, on the fork of a bois mande tree.

The view from up there was fascinating. The grassy expanse of the swamp, far below, rolled gently toward a distant fringe of mangroves; at hands-reach we could admire the white and yellow blossoms of a guatecare tree and a cluster of orchids, while bromeliads and ferns grew on a multitude of suitable crotches. As we climbed higher still, waves of foliage met our eyes in all directions. Birds never seen near ground-level were common. Their relative lack of concern for our presence suggested that they had not yet been warned of man's willingness and ingenuity to harm them. Here we were in the parrots' world and could see the birds that shared it. Red-bellied macaws, their green-blue bodies sleek and swift, flew overhead in considerable numbers; in late afternoon they converged toward their communal roost to spend the night. We were level with the nest of a grey hawk, and further away we could spy the activity around a colony of yellow-tailed oropendolas, their tear-shaped nests swaying gently in the breeze. A black-and-white woodpecker probed the bark on a nearby branch, while in a tangle of vines, unseen, a toucan persistently repeated its metallic "piok!"

Do parrots imitate any of these neighbors? Our field observations on the orange-winged amazon and the red-bellied macaw suggest that neither of these birds imitates other species in the wild. This does not necessarily mean that their vocal abilities go unused. Amazons nesting within audible range from each other share many of their calls and will on occasion answer each other with a very close replica of the same vocalization. These, of course, are only partial impressions collected during the first stages of our study. However, it seems likely that when a tame parrot imitates its proud owner, the latter is just being treated like another parrot. In the auditory and social deprivation of a captive life without other parrots, these birds may even imitate other environmental sounds, transfering attention which otherwise might have been focused entirely on members of their own species.

Holding his binoculars high and dry, Dr. Nottebohm wades through the tepid waters of the Nariva Swamp; fortunately leeches are not very common (top).

Access to Bush Bush is by boat; before reaching the island, the boat-line cuts through lush swamp forest (above, left).

One way to observe parrots at close quarters was to ascend to their treetop habitat; by climbing the ladder, the authors reached their blind 70 feet about ground, high above the jungle floor (above, right).

Quite possibly, parrots use their imitative powers in still another way. As we visited a mountainous area some 30 miles north of Bush Bush, parrots abounded there, but their high pitched whistling calls sounded like nothing we had heard before. This, we decided, must be another species. As we focused our binoculars, much to our surprise, we recognized our friends, the orange-winged amazons. We now have seen this phenomenon repeat itself in still other areas in Trinidad. Preliminary evidence suggests that we have here true dialects which correspond to different populations of the same species.

Is it possible that each individual has to learn the dialect of its population? To explore this possibility we have hand-reared 12 amazons taken from their nests in Trinidad at various ages after hatching. If these birds fail to produce as adults the sounds characteristic of the population from which they came, this would indicate that a good number of their vocalizations in the wild are learned from older members of their group.

The observations reported here merely scratch the surface of the many tantalizing problems posed by the natural life of parrots. Unfortunately, in the course of our work in the field we became aware of another problem, the unpleasantness and urgency of which cannot be overstated.

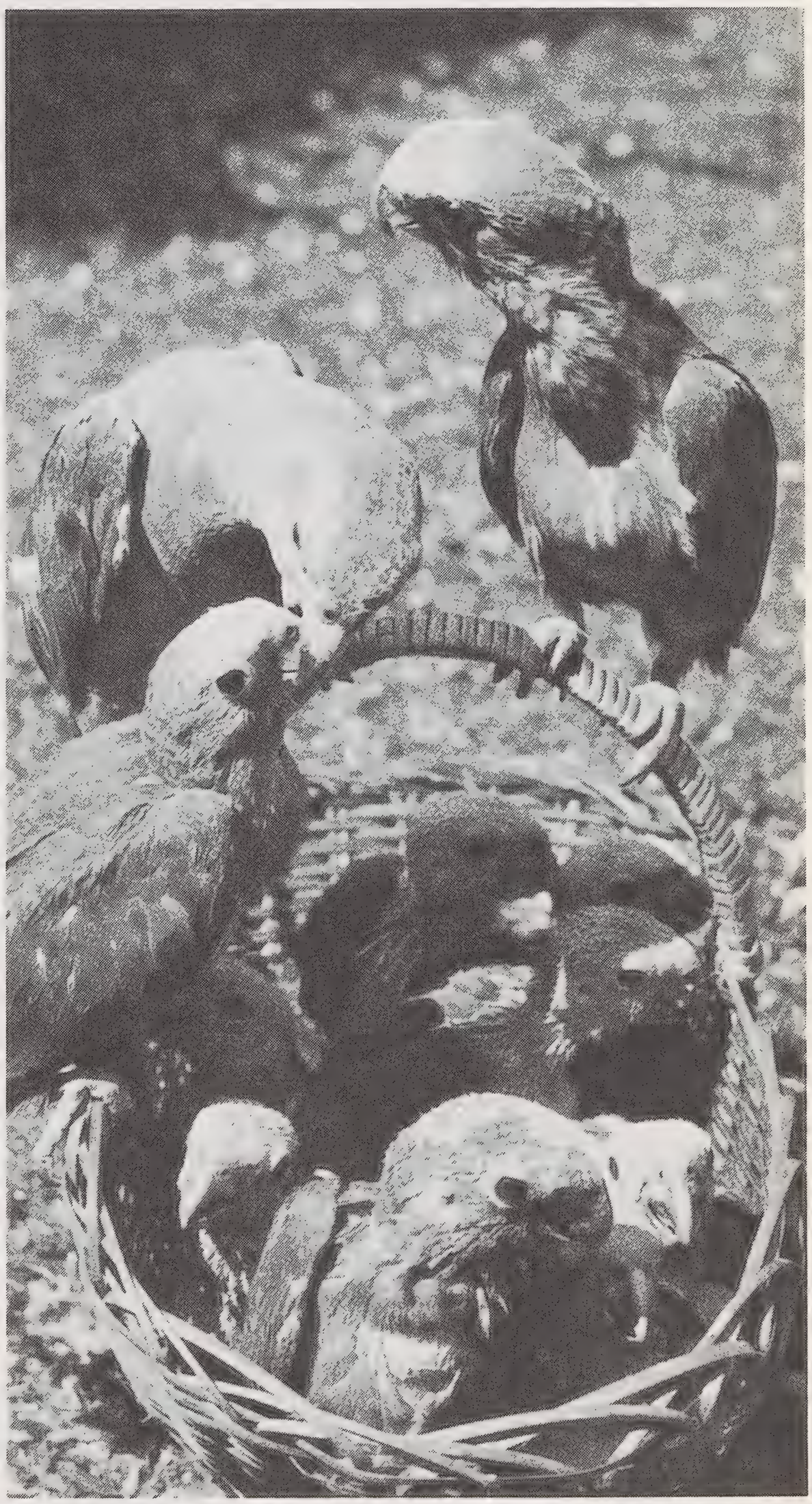
In Trinidad, as in many other places, parrots are the focus of a cruel and destructive pet trade. Trees bearing nest sites are torn down to obtain the young. Since potential breeding sites for hole-nesters seem usually scarce in nature, loss of adequate nesting facilities seriously affects the breeding success of the species concerned.

Virtually all parrots sold as pets are hand-reared. In their eagerness to secure a crop of nestlings, collectors often take the young amazons or macaws from their nests at an age when hand-rearing almost inevitably fails. Other nests, also prematurely pillaged, only contain unhatched eggs. Commonly the tree or palm stump bearing the nest is 40 to 60 feet tall. As it comes crashing down most of the birds inside are killed or seriously injured. It is frightful to consider the tremendous destruction and cruelty that must be suffered for each young parrot that reaches the pet dealer's stand. Needless to say, mortality thereafter continues at a brisk pace.

This state of affairs, complicated by an irreversible destruction of natural habitats, has brought great danger to Trinidad's parrots and macaws. One of the rarer species, the majestic blue-and-yellow macaw, of which only some 15 birds survive in the Nariva Swamp, may soon disappear from the island.

Yet, there is still some room for hope. In an attempt to protect its rapidly diminishing natural resources, the Trinidadian government recently declared Bush Bush and neighboring parts of the Nariva Swamp a game sanctuary. In time the Nariva Swamp could become the Everglades of the Caribbean. Visitors may come from far away just to enjoy the sight and sound of howler monkeys, capuchins, agoutis, deer, or peccaries; of caimans, toucans, oropendolas, trogons, hummingbirds, and the incomparable beauty of undisturbed forests and swamplands.

We are still studying the parrots of Bush Bush and hope to learn much more about their lives. If



When Cocotte, the authors' pet amazon, sees the twelve nestlings, it softly holds their beaks and tries to feed every one of them.

the status of Bush Bush as a game sanctuary is enforced, prospects for research are good and may draw other scientists to work on other problems.

It is fascinating to see how parrots live and to hear their untamed voices ring over their native land. We hope future generations will have a chance to enjoy these sights, these sounds.

SAGA OF THE SAIGA

BY JOHN HILLABY

With rare foresight, a few Russian biologists have saved a curious species of antelope—one with a grotesque nose that seems to combine the functions of a dust extractor with that of an air warmer and humidifier. The animal is the saiga which, after hovering precariously on the brink of extinction, has been resurrected to such an extent that it is now by far the commonest ungulate in the USSR, where it is regarded as a considerable natural resource.

Up to 40 percent of the present stock can be harvested annually without endangering capital stocks, even taking into account the losses from natural causes. The Russians are proud of their achievement and talk of the saga of the saiga. Propaganda? Not at all. Dr. Bernard Grzimek, director of the Frankfurt Zoo, says the number of saiga to be seen in Kazakhstan nowadays is a miracle.

There are too few of these success stories to allow even one to go unnoticed. Each year, it has been calculated, one species or subspecies of either the mammals or the birds becomes extinct.

On the positive side, conservationists can point proudly to the return in zoos and sanctuaries of Père David's deer from the last few discovered in the Royal Hunting Park outside Peking; to Przewalski's horse; to the European bison; to the Arabian oryx, being successfully reared now in Arizona after facing extermination in the Arabian desert; and to the saiga *(Saiga tartarica),* now being culled in controlled "cropping" ventures at the rate of about a quarter of a million animals per year.

In appearance there is nothing quite like the saiga. It is about two feet, six inches in shoulder height; the muzzle is hairy; the horns of the males stumpy, ringed, and in-turned or lyrate towards the tips; and the coat is heavy and wool-like with a fringe of long hairs extending from the chin to the chest. The inflated, downward-pointing nose of both sexes looks somewhat ludicrous. In each nostril there is a sac lined with mucous membranes.

Opinions differ about the function of the inflated nose and associated structures. It may be an adaption for warming, moistening, or even sensing the humidity of inhaled air in such a way that saiga can detect the onset of distant rain; or then again it may enable them to browse on low-growing and rank shrubs and grasses on dusty plains. The nose is said often to contain grains stuck together with mucous. In their shambling gait, whether walking, trotting, or galloping, saiga carry the head down, but if alarmed they can race off at speeds estimated at 30 or 40 miles-an-hour.

In Upper Pleistocene times of about a hundred thousand years ago, a time when wooly rhinoceros and hairy elephants were still plentiful across much of Europe, the range of the saiga, as shown from fossil evidence, extended from south-east England, across Poland and Russia, to Kamchatka and western Alaska.

According to Professor A. G. Bannikov of Moscow, who has probably done more than anyone else to encourage what are now vast numbers of these curious antelopes, the range of the saiga was reduced enormously by climatic and associated weather changes in the immediate post-glacial millenia. The northern parts of the steppe became first wet and soggy and then clothed in dense and vast areas of birch. In many places the saiga were unable to migrate and were, therefore, confined to regions where they were wiped out in winter. Sustained snow kills them. In later times they were hunted by the nomadic tribes of Asia—the Scythians, the Tartars, the Mongols, Kirghiz, Kazakhs, and so on. There was also a flourishing trade in horns for export to China where, ground into powder, the commodity, like so many others, is believed to have aphrodisiac properties.

In the middle of the nineteenth century, the slaughter reached prodigious proportions. Often the animals were shot, de-horned, and so great was the apparently inexhaustible supply of meat, their bodies were simply left to rot where they fell. The Khirgiz hunted them with deer hounds and trained eagles; other tribes contrived to drive herds of many thousands of animals between ever-narrowing lines of fencing. The necks of these traps terminated in spear-lined pits and sharpened staves that projected from the fencing so that in running through this gauntlet the animals were literally ripped apart. In addition, they suffered the usual natural disasters, especially during severe weather when the few survivors, the nucleus of the region's future stocks, were killed off by man.

By the beginning of the present century, the formerly abundant saiga had been reduced to a total population of probably not more than a thousand head in a few widely separated and remote parts of southern Russia, such as the Kalmyk area west of Astrakhan and Soviet Central

The head of the saiga is dominated by the large downward-pointing nose; in each nostril is a sac lined with mucous membranes.

Asia in the vicinity of the Ustyurt plateau, the Sarysu valley, the Bet-Pak-Dala steppe, and the Ili-Karatal region.

In 1919—notwithstanding acute internal strife—a few Russians forsaw that the saiga was doomed unless immediate steps were taken to save the species. A decree was passed forbidding the hunting of saiga anywhere. This was a remarkable ordinance. The law, of course, was unenforceable in the outermost parts of the country, but there the migrant tribes had other things to think about than the pursuit of a few elusive animals. For 10 years the relic population of saiga remained fairly stable due, it is thought, to the geographic isolation of the survivors and a succession of hard winters.

During this period, Professor Bannikov and his colleagues initiated a nation-wide survey, perhaps one of the biggest ever undertaken, to find out what they could about the animals' reproductive biology and behavior, especially where and under what conditions they migrated. Young saiga were captured, tagged, and released; the remnant herds were shadowed from trucks and from the air in flimsy planes. The location of all known groups were mapped month by month so that gradually the pattern of movement became reasonably clear.

Saiga antelope, the Russians found, were almost constantly on the move. To this fact, combined with high fertility and what seems to be food priorities for pregnant females, and, of course, the protection the Russians afforded them, they owe their survival.

The animals are extremely sensitive to the slightest change in the weather, particularly the onset of long periods of drought or snow.

Mating begins in late November when the bucks collect harems and engage rivals in violent butting contests. They seem to prefer older mates to the younger ones. Males eat little during the rutting season. For this reason they face winter in a debilitated condition and frequently die. The mortality has an invigorating effect on the stock as only the strongest males survive. In the winter and early spring, the pregnant females seem to eat most of the scant herbage available. They are highly fertile and frequently give birth to twins.

By 1940 the saiga population of Kazakhstan had risen to the level of what it was reckoned to have been a hundred years earlier; in 1950 it was 750,000, and in 1960 it had reached a figure in excess of a million-and-a-quarter. In southern Russia, too, the spread in area and numbers was phenomenal—in 1958 there was estimated to be 540,000 animals west of the Volga River. The saiga is now so common that it has to be cropped to prevent the herds from becoming an agricultural pest. This is done by issuing conventional hunting licenses during the short hunting season—October and November—while at the same time, national and state organizations, such as the famous Astrakhan *Okhotpromkhox,* ensure that capital stocks are not endangered. At the moment, the saiga is still increasing in numbers.

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

FOR THE RECORD:

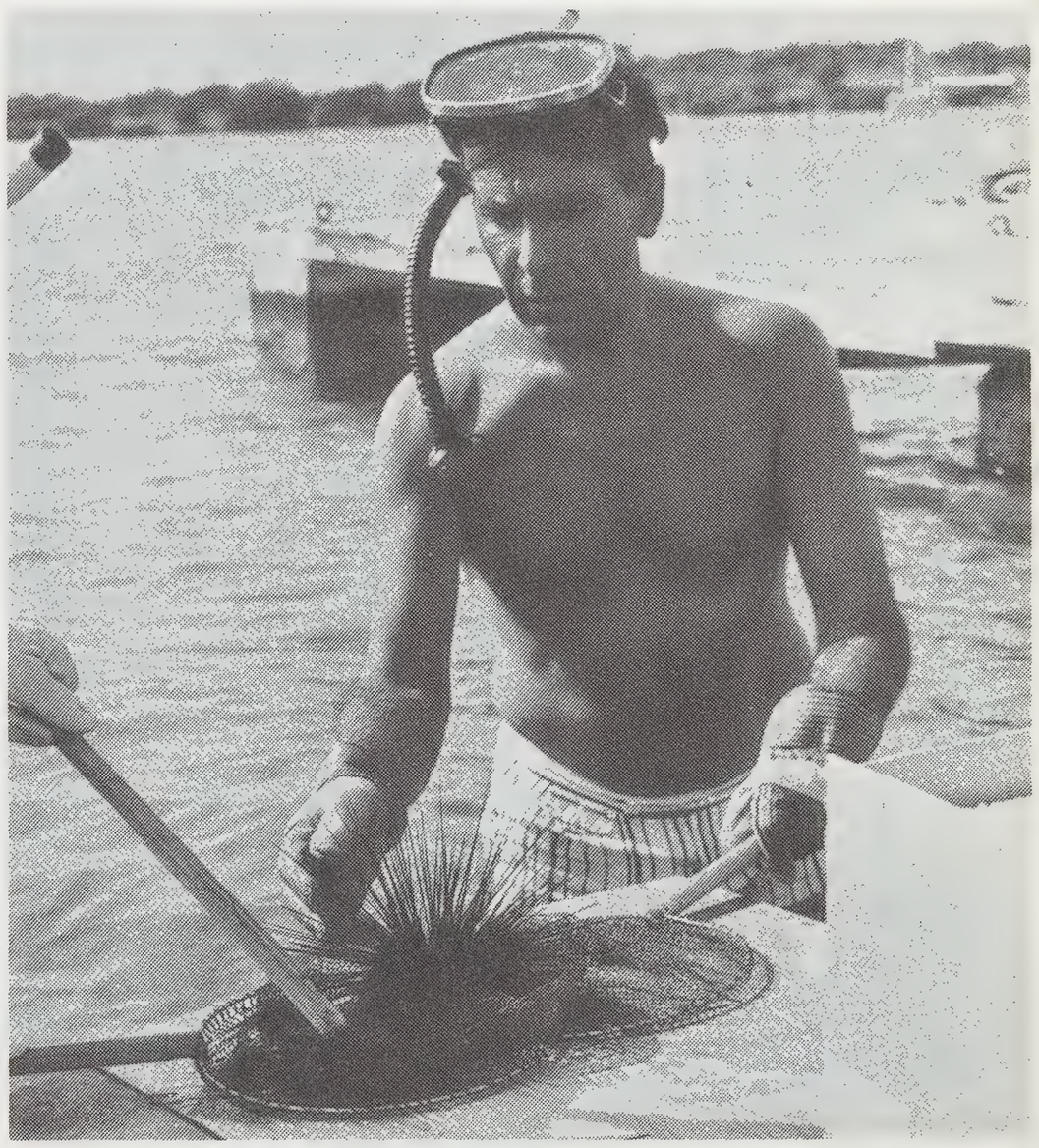
"I'm amazed at the publicity for the loss of a few birds."

Fred Hartley
President, Union Oil Company

"The tide of the earth's population is rising, the reservoir of the earth's living resources is falling. Technologists may outdo themselves in the creation of artificial substitutes for natural subsistence, and new areas, such as those in tropical or subtropical regions, may be adapted to human use, but even such recourses or developments cannot be expected to offset the present terrific attack upon the natural life-giving elements of the earth."

Fairfield Osborn
Chairman of the Board of Trustees
New York Zoological Society

(From the forward, *Our Plundered Planet,* 1968 edition.)



British Virgin Islands – Dr. George D. Ruggieri, S.J., Coordinator of Research of the Osborn Laboratories of Marine Sciences, is shown examining a sea urchin during a New York Zoological Society expedition to collect marine animals for research at the laboratories and for exhibition at the New York Aquarium.

A Million Animals a Day Killed by Cars

Washington, D. C. – More game in the United States is killed by motorists with cars than by hunters with guns. In 1968 at least 365 million animals, most of them wildlife, were struck and killed by vehicles in the United States, according to a report made by the American Automobile Association.

An A. A. A. spokesman said that during a single day in Florida, state authorities reported 5,000 quail, 250 turkeys, and 2,000 squirrels, rabbits, songbirds, rodents, and reptiles as victims of motor vehicles.

Genetically Identical Fish Developed

Brooklyn, N. Y. – A strain of fish whose individuals are totally identical genetically has been produced at the Osborn Laboratories of Marine Sciences after 30 years of inbreeding.

The 50th inbred generation of the strain of platy fish has been born in a tank at the genetics laboratory of the Osborn Laboratories, sister institution of the New York Aquarium. After three decades of brother-to-sister mating all tissue incompatibility has disappeared between individual fish in the strain, which has been designated JP-30.

"There is no more genetic variability at all," says Dr. Klaus D. Kallman, fish geneticist at the laboratories. "The JP-30 fish are identical to one another in every respect, right down to the last cell."

Because of their genetic compatibility the JP-30 fish are excellent subjects for research in organ transplantation. Dozens of successful transplants of fins, hearts and gonads have been performed on members of the strain, which is in much demand by medical research laboratories. Breeding stock of the strain has been shipped to laboratories in the United States and in Turkey, Poland, and Germany.

The JP-30 fish are descendants of a pair of platy fish collected near the mouth of the Rio Jamapa in Vera Cruz, Mexico in 1939. Although genetically unusual, the JP-30 platy fish *(Xiphophorus maculatus)* are physically quite undistinguished, measuring about an inch in length. Their body color is brown, that of the dorsal fin dull red.

A key stumbling block to successful tissue and organ transplantation in humans has been the body's natural tendency to destroy foreign cells in the same way it fights infectious disease. Chemical antibodies in the body cause rejection of the transplant in many cases. Because of the identical genetic constitution of the JP-30 fish, rejection does not occur when tissue is transplanted from one individual in the strain to another.

Philadelphia, Pa. – Massa, the Philadelphia Zoo's male silverback gorilla has celebrated his 38th birthday. He is believed to have been born in January 1931 and is the oldest gorilla in captivity. His nearest rival for longevity, M'Toto, a female belonging to a circus, died last September at an estimated age of almost 37 years. The second oldest gorilla in captivity now is probably the Bronx Zoo's female, Oka, who will celebrate her 29th birthday this spring.

Off to Komodo to Study Monitors

Bronx, N. Y. – A noted American herpetologist will spend a year studying the giant Komodo monitors, world's largest living lizards, on a remote Indonesian island. The New York Zoological Society has selected Dr. Walter Auffenberg of the University of Florida, to conduct the study of the behavior and ecology of the giant reptiles. He will observe the monitors – wrongly nicknamed "dragons" – in their natural habitat on the island of Komodo.

Dr. Auffenberg's wife and three of his four sons will accompany him on the year-long project. The study, sponsored by the New York Zoological Society and by the Charlotte Ordway Fondaras Wildlife Protection Fund, could be critical in ensuring continued survival of the Komodo monitors. Many conservationists fear the huge monitors will soon be threatened with extinction. Less than 1,100 of the monitors are believed to exist on Komodo and on the nearby islands of Padar, Rintja, and Flores.

Monitors are protected by the Indonesian government but, according to Dr. F. Wayne King, curator of herpetology of the New York Zoological Society, until more is known about the behavior, ecology, and life history of the animal, little can be accomplished in the way of a management program. Dr. King conducted a preliminary study of the monitor population on Komodo in April, 1968.

The giant monitors weight up to 250 pounds when adult. Males reach a record length of 10 feet, 2 inches; the record female monitor measured 7 feet, 6 inches.

Dr. Auffenberg and his family will leave in July for the island of Komodo. There is only one village on the arid island, with approximately 300 people. A thatch-roofed house will be constructed for the Auffenbergs outside the village at a site to be chosen for its proximity to the monitors and to a water supply.

Dr. Auffenberg is currently chairman of the Department of Natural Sciences and curator in herpetology of the Florida State Museum, a department of the University of Florida, Gainesville. He is also a professor of zoology with the University. Recently elected a research associate in herpetology of the New York Zoological Society, he has published many papers on fossil and living reptiles and amphibians. His recent studies have been on the behavior and ecology of living tortoises and the anatomy and morphology of living and fossil tortoises.

THE bookshelf

BIOLOGICAL CONSERVATION, *a new scientific quarterly. Nicholas Polunin, editor. Elsevier Publishing Company, Ltd., Ripple Road, Barking, Essex, England.*

A new scientific journal has come upon the scene. In a day when virtually every scientific discipline, comprehensible and otherwise, has its own technical publication (more often than not, publications) such an announcement is hardly likely to generate widespread rejoicing. But in the case of *Biological Conservation* – the first issue was October '68 – it should.

To this man's mind, *Biological Conservation* has a *raison d'etre* few other journals can match. Its subject is the Earth as an ecosystem and, going to the antipode of today's super-specialist journals, *Biological Conservation* seems to revel in its willingness to consider the problem from the myriad points of view the problem itself implies. Here is a journal that declares in its opening editorial statement that it is "as all-embracing as possible." If it sticks to its guns, it will, and indeed it must, be.

Biological Conservation's editors say it is concerned with "conservation" in its widest sense – keeping, insofar as practical, what we have, restoring what it is possible to restore, and the intelligent use of the available inventory of biological resources.

Its basic viewpoint is, of course, ecological, and it states as its main purpose the widest possible dissemination of original papers on the preservation of wildlife and of all nature, and the wise use, on a global scale, of biological and allied resources. At the same time it lends its pages to reports, articles, and papers on any of the factors that affect the disposition of the earth's natural resources.

This means that along with research reports by the working scientist will be accounts and surveys of pertinent economic, social, and related developments. The politician, legislator, lawyer, editor, interested layman, and innumerable others can directly influence bioconservation, and by opening its pages to other than research reports, *Biological Conservation* takes note of this all-important fact.

Of course, not all scientific journals should take so wide an approach, but then the subject makes the difference. The fiscal axe of the legislator can, for instance, wipe out a new controlled-fusion device while it is still on the drawing board, but it is not possible to legislate plasma physics out of existence. Negative action on a piece of conservation legislation, however, can mean an end to existence for a species of animal.

Meanwhile, the editors of this journal admit that it is difficult to define exactly what comprises "biological conservation." So they have provided an answer of their own. They list 30 subject headings to which the journal is addressed, and these include such diverse topics as population dynamics; threatened species; botanical and zoological gardens (it is gratifying to note the journal's attention to the place of the zoo in conservation); education and training – including the use of public relations and publicity; wetlands; tourist and recreation effects; and international implications.

At about this point a question may be in order: Why review a technical journal in *Animal Kingdom*, a publication of popular bent? Because, although *Biological Conservation* is not a "popular" magazine, its diversity and, more to the point, its creative presentation of papers, notes, and articles make it extremely readable.

Reading *Biological Conservation* is not a task (although it will lead to a greater awareness of the progressive destruction of the environment, which certainly is depressing). Then, too, it has a fresh visual format, easy to look at.

The first issue opened with an editorial statement and an editorial. It had 13 papers (two in French, the remainder in English), 13 "Conservation Around the World" shorts, and more typical material such as a "Notes, News, and Comments" section.

At best a journal of this type could provide a springboard for particular conservation campaigns coordinated on a global basis. At the least, it is an agreeable way to keep informed about a subject which in coming decades may well compete with the space program for news coverage. E. R. R.

BLACK JACK, LAST OF THE BIG ALLIGATORS. *By Robert M. McClung. Illustrated by Lloyd Sandford. 64 pp., 39 illustrations in black-and-white. William Morrow and Company, New York, 1967. $2.95.*

Robert M. McClung's book, *Black Jack,* is factual throughout and cleverly presents a wealth of information, in the text and in its very meaningful illustrations. Some of the figures are clear and detailed. The Afterword, which seems to be directed toward the older reader, discusses the plight of the American alligator in recent times as understood by the author. The young reader will certainly find this book interesting and stimulating. However, the addition of a suggested reading list relating to reptiles would greatly increase its value.

Peter Brazaitis

SOCIAL ORGANIZATION OF HAMADRYAS BABOONS. *By Hans Kummer. 189 pp. The University of Chicago Press., Chicago, 1968. $8.95.*

In this monograph, Hans Kummer presents the results of a 12-month study of free-ranging hamadryas baboons. Kummer and his assistant surveyed the composition and ecology of 23 troops in eastern Ethiopia, and then settled down to an intensive study of one troop in which they could eventually identify about 40 individual baboons. They found that the basic social unit of the hamadryas is a group containing a single adult male and several females with their young. At night a number of these "one-male units" join together and sleep on cliffs in larger troops of around a hundred animals. The hamadryas baboon thus differs from its better studied relative, the savannah baboon, which lives in stable groups of approximately 40 animals, including a number of adult males. Kummer includes in this report descriptions of how a young adult male sets about to establish his own group and of how a recognized leader keeps his group together with occasional bites on the necks of straying females. One of the most intriguing aspects of the "one-male unit" is the synchronization of the monthly cycles of the females in each small group. Throughout the text, Kummer illustrates general points by relating actual sequences of behavior he observed. The book also includes numerous photographs and diagrams. It is a thorough and enjoyable presentation of an exciting field study.

Richard Zigmond

BIRDS OF EUROPE. *By Bertel Bruun. Illustrations by Philippe Degrave. 160 pp. Golden Press, New York, 1967. $1.25.*

This guide to the birds of Europe is small, compact, and reasonably priced. The illustrations, although not the best, are all done in color and make recognition easy. The small distribution maps are quite nice and should prove very helpful. The common names and scientific names all seem fairly accurate. Giving both common and scientific names is a very good feature of this guide. In general this golden guide should prove helpful to anyone interested in the birds of Europe.

Don Bruning

DIE STRASSEN DER TIERE. *Heini Hediger, editor. 313 pp. Friedr. Vieweg and Sohn, Braunschweig, Germany, 1967.*

Most of us think of wild animals as "free ranging" — antelope wandering over the great expanses of Africa or fish swimming through the seven seas. This is, however, not usually the case. Most animals spend a great part of their lives within relatively small regions or territories. Within these areas the movements of many animals are further restricted to surprisingly distinct paths. Dr. Hediger's primary interest is in these paths or, as in the title of the book, "the streets of the animals." The first chapters in this book deal with these paths as observed both in the wild and in zoos. Soon, however, the outlook of the authors broadens to include discussion of the territories of various animals from mice to lions. Shortly after this, we jump to a consideration of the migratory movements of fish, birds, insects, and bats.

The symposium thus attempts to cover all movements of all animals and falls short of this goal. In particular, there are several what I consider to be glaring omissions by the authors. Of perhaps greatest importance is the lack of a review of the sensory mechanisms concerned with bird migration, and the omission in Lecomte's short paper on bees of any mention of the work of von Frisch. In addition, the movements of birds and bats over short distances, flocking behavior, and the repeated use of certain routes by these animals would seem relevant to the subject matter of the book.

Despite the limitations mentioned above, *Die Strassen der Tiere* contains many scholarly reviews of the movements of certain animals. I particularly appreciated Dr. Roer's review of the movements of bats, which is the most complete to date, as well as his treatment of the movements of insects. Among

others, the reviews of the movements of fish, reptiles, and amphibians, and Schmidt's treatment of the tunnels and paths of ants and termites seemed thorough.

Perhaps the greatest value of this collection is in the great scope which Dr. Hediger has seen fit to give the study of the movements of animals. Despite the omissions, and the somewhat tenuous connection between subjects, chapters on the movements of several mammals, lower vertebrates, birds, insects, and even the spread of plagues and the dispersion of presently extinct species are brought together; the juxtaposition of these subjects and the search for similarities between them must stimulate any reader.

Timothy C. Williams

VANISHING WILD ANIMALS OF THE WORLD. *By Richard Fitter. 144 pp. 43 full-page color illustrations by John Leigh-Pemberton. Franklin Watts, Inc., New York. $7.95.*

It is obvious that book publishers, always quick to pinpoint a trend, feel that the number of people interested in the preservation of rare wild animals is increasing. Lately the market has been flooded with books on the plight of wildlife. Not all of these books, of course, are worth having. That by Richard Fitter, reviewed here, certainly is.

To begin, however, the title *Vanishing Wild Animals of the World,* is somewhat misleading. The book is, in the author's words, "restricted to mammals . . . " and the animals covered are "mainly the 271 mammals officially listed as being in danger of extinction in June 1967 in the Red Data Book of the Survival Service Commission of the International Union for Conservation of Nature."

The book has a foreword by the Duke of Edinburgh and an introduction by Peter Scott, chairman of the World Wildlife Fund. Mr. Scott surveys some of the work of various international conservation organizations.

Part 1 of the book is devoted to "vanishing animals, and why they vanish" and establishes the background for what is to follow. Part 2, the core of the book, surveys endangered animals by zoogeographic regions. The book is a survey, so it is unfair to demand detailed treatment of each animal described, but in scope of coverage Mr. Fitter's book is comprehensive and very much up to date. Moreover, the author—very much intentionally, it seems—does not dwell excessively on the technical aspects of zoological classification that could slow the pace of the book for the lay reader. He does, however, include the scientific names of animals he discusses.

After his survey of endangered mammals, Mr. Fitter demonstrates that endangered animals can indeed be brought back from near-extinction. In Part 4 of his book he documents cases of animals—the bison and the saiga, for example—that have been saved.

Next, in the final major section of the book, he discusses the interwoven factors involved in preserving wildlife. The final portion, "How endangered animals can be saved," devotes considerable space to zoo breeding programs and other efforts to propagate wild animals in captivity. There are three useful appendices—one an indexed list of extinct, endangered, and saved mammals; the second listing prominent conservation organizations; and the third containing suggested reading. Unfortunately the illustrations are not particularly good.

E.R.R.

ABOUT THE authors

Alicia Armstrong is a reporter for the *Milwaukee Journal* whose articles about the Milwaukee Zoo appear regularly in that newspaper. **Joseph A. Davis, Jr.**, is scientific assistant to the director of the New York Zoological Park. **Edwin Gamble**, a member of the New York Zoological Society, is an artist with a special interest in birds. His drawings of shore birds that appear in this issue were made in the Aquatic Birds Building of the Bronx Zoo. **John Hillaby**, whose articles have appeared several times in *Animal Kingdom,* covers biology for the *New Scientist.* **Carl B. Koford** is a research zoologist at the Museum of Vertebrate Zoology, University of California, Berkley. **Fernando Nottebohm** is a member of the staff of the Institute for Research in Animal Behavior. His wife, Marta, is serving as his research assistant. The Nottebohms recently returned to Trinidad for additional field studies of their parrots.

ILLUSTRATION CREDITS

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Mr. Gamble's remarks on page 15 are reprinted with the permission of Egan Gallery, New York City.

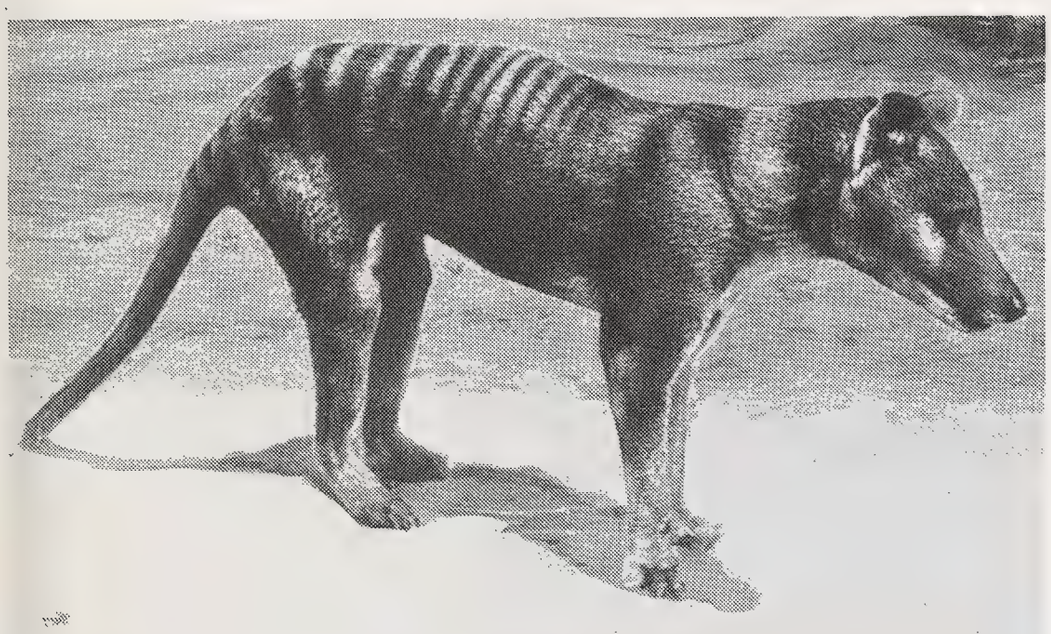
This is the first in a series of articles on:

Dying Species . . .

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

THYLACINE
(Thylacinus cynocephalus)



During its long separation from the rest of the world, Australia saw the rise of a unique mammalian fauna, representatives of a handful of marsupial families which mirrored the ecological diversity of the placental mammals. Without the competition of their placental counterparts, the marsupials flourished, secure in the isolation provided by the inaccessibility of the Australian land-mass.

The thylacine, or marsupial wolf, was one of the inhabitants of this marsupial Eden. Sleek-haired and grayish-tan with about a dozen-and-a-half short transverse darker stripes across the back, the thylacine measures four feet long exclusive of its tapering foot-and-a-half tail; it is about the size of a coyote, but with somewhat shorter legs.

The thylacine arose from a carnivorous family, whose other members range from mouse- to cat-size, filling the opportunity for a predator big enough to prey upon the larger marsupial herbivores, the kangaroos. It formed a necessary part of the ecosystem.

The last specimen collected was taken nearly 40 years ago, so knowledge of its life history is considerably more fragmentary than for most mammals. Old reports tell of thylacines being nocturnal and hunting singly, in pairs, or in groups. Two to four young, born at no set time of year, appear to be the rule. Although they normally have a quadrupedal gait, hard-pressed individuals have been reported to hop along, kangaroo-like, on the hind feet alone.

The thylacine's confrontation with man spans a vast period of time. The first threat to its existence was man's domestication of dogs, ancestors of the dingo and New Guinea dogs which accompanied the earliest human immigrants to Australia and New Guinea during the Pleistocene. Once there, the dogs were so much better at hunting and pursuing prey that they simply edged the thylacine out. By the time the English discovered Australia, the thylacine existed only on the large island of Tasmania, where the dingo was unknown.

With the advent of European agriculture, the thylacine added sheep and poultry to its fare of native prey and thereby brought upon itself the unrelenting vengeance of man, to whose person it posed no direct threat. Bounties were paid and 2,268 thylacines were known to have been killed between 1888 and 1924.

At the turn of the century, this marsupial wolf was still fairly abundant in the grazing country of the central plateau of Tasmania and was known in other regions as well. Since then, as a result of hunting, disease, and destruction of habitat, the species has been thought to be extinct, but there have been scattered and persistent sightings in the western part of the island. Some of the reports may have been erroneous, but there have been a sufficient number of sightings to reasonably establish the survival of the species.

Today a heavy penalty is prescribed by law for anyone killing a thylacine, and a million-and-a-half acre reserve in southwest Tasmania was authorized in 1966 for its protection. There may still remain a chance that future generations will be able to see this fine example of convergent evolution.

JOSEPH A. DAVIS, JR.

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animal kingdom

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animal kingdom

MAGAZINE OF THE NEW YORK ZOOLOGICAL SOCIETY VOL. LXXII NO. 2 APRIL, 1969

ABOUT THE COVER

Front: The cheetah *(Acinonyx jubatus)*, to bring down its prey, erupts with a lightning burst of speed that no other four-footed animal can match over a short distance. Dr. George Schaller has observed the hunt of the cheetah first-hand. He describes how the cheetah stalks and obtains its prey in the article starting on page 2.

Back: Sea anemone *(Anthopleura elegantissima)* occurs in great numbers in tide pools, attached to rocks and sometimes partly buried, along the northeastern Pacific shore.

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by George B. Schaller

THE HUNT OF THE CHEETAH

Shortly after dawn the female cheetah, her two small cubs beside her, rose and looked imperiously across the vast Serengeti plains. Scattered groups of Thomson's gazelles grazed about 800 feet away, oblivious of the predator nearby. Suddenly the cheetah trotted in a semi-crouched posture to within 300 feet of the gazelles. She halted briefly, hidden behind a tuft of grass, advanced 60 feet, then another 60 feet, and crouched, motionless. Closest to her and somewhat apart from the other grazers was a large gazelle fawn. The cheetah waited. Finally when the fawn faced completely away from her, she sprinted forward. The gazelle fled, but after a run of 700 feet, during which the fawn almost escaped by dodging sharply several times, the hunt ended in a cloud of dust from which the cheetah emerged holding her victim by the throat. She dragged it to the shade of a tree and lay there panting from the exertion of the hunt while her cubs tore excitedly at the carcass.

As the fastest of all land mammals and the only cat able to run down its prey with a tremendous burst of speed, the cheetah has for a long time fascinated me and I have observed it whenever

Dr. Schaller's research is financed by the National Science Foundation and New York Zoological Society. Local cooperation is being given by the Serengeti Research Institute and the Tanzania National Parks.

The female cheetah waits and watches on the plains of Serengeti National Park for a potential prey animal to wander into her vicinity (left). Her two cubs turn a small tree into a jungle gym (center). Successful in her hunt, the cheetah carries a young Thomson's gazelle, her principal prey, back to her hungry cubs (right).

possible. So when a female with her cubs settled down for awhile near our home in the Serengeti National Park, I watched her hunting behavior for 26 days. Then, like most other cheetahs in the park, she left our area, apparently to follow the nomadic movements of her principal prey, the small Thomson's gazelle.

Of the 136 cheetah kills I have recorded, 89 percent were Thomson's gazelles, the remainder consisting of impala, wildebeest, reedbuck, topi, dik-dik, and hare. Most prey are the small species of antelope or the young of large species weighing 130 pounds or less. With its small jaws and teeth, the cheetah—when hunting alone as it usually does—undoubtedly finds it difficult to subdue such large prey as adult wildebeest. However, at times two or three males or a grown litter hunt together and these may attack large prey. A group of four males in Nairobi National Park were known to kill zebras.

The female cheetah whose hunt has just been described spent much of the day resting, as is usual among predators, lying beneath a bush or hidden in a patch of grass. At times she moved a few hundred feet to another site. Even when seemingly hungry she made little effort to search for a victim, but waited instead for one to wander into her vicinity. Usually she traveled only a mile or so in the daytime and little or not at all during the night. Since a cheetah hunts by sight alone, most of its activity is confined to the daylight hours: about 60 percent of the kills are made between

One of the cubs starts to tear at the carcass of a hare just killed by the female cheetah (left). While the cubs eat their meal, the female keeps watch for other predators such as lions and hyenas which might attempt to appropriate the kill by driving off the more timid cheetah (right).

dawn and 10 A.M., and the rest at anytime until dusk. Rarely a cheetah may hunt on bright moonlight nights.

Although the cheetah can run at about 60 miles per hour and the Thomson's gazelle at approximately 45 miles per hour, the race is not as one-sided as it may seem. The gazelle has great stamina, whereas the cheetah can maintain its speed for only about 600 to 900 feet before having to stop, exhausted. Therefore, the cat must be fairly close to a potential prey animal before beginning the pursuit.

Sometimes the female cheetah merely walked toward a herd of gazelles without concealing herself. The gazelles watched her alertly, snorted in alarm, fled a few feet, only to halt and perhaps to venture closer—seemingly out of curiosity. The cheetah in turn often made brief rushes at the animals as if to scatter them and separate one from the group. (Several times I have seen a cheetah give up a chase when its selected victim escaped by mingling with a herd.)

At other times, the cat dashed at the unsuspecting animals from a distance of between 300 and 600 feet. By the time the gazelles became aware of the danger, she was often close enough to pursue one individual at full speed. A third method, and one the cheetah used most commonly, was to stalk toward the gazelles in typical cat fashion, body pressed to the ground, using all available cover but paying no attention to the direction of the wind, until finally she attacked from close range.

The cheetah gives chase to drive off the vultures waiting to scavenge the remains of the cubs feeding (above, and at right); the sudden and rapid descent of the birds from the sky is a signal to the other predators in the area of the presence of meat.

To see a cheetah in full pursuit of its prey is one of the most exciting sights in Africa. While the gazelle zig-zags, the cat tries to follow each unpredictable turn. Then, when near enough, a forepaw flashes out, slaps a hindleg or flank, and the gazelle crashes to the ground. An instant later, the cheetah has it by the throat and strangles it.

The main defense of the gazelle is its ability to dodge sharply. If the cheetah fails to follow a turn, it usually loses too much ground and momentum to continue the chase. Once the female slipped and fell in a tight turn. I watched 29 pursuits after adult gazelles and in only 48 percent of these was the cheetah successful. On the other hand, of 11 chases after small gazelle fawns, all ended in kills. No wonder that the cheetah selects a young animal whenever it has a choice.

Once my wife Kay observed the female as she gave her cubs, then four months old, the opportunity to hunt and kill. The adult cheetah carried a kicking gazelle fawn to the cubs and dropped it. When the fawn jumped up and fled, the female merely watched while the cubs chased it and once knocked it down. They were unable to hold it, and finally the female ran over and killed it.

The meat on one flank of the victim is usually eaten first, followed by that of the abdomen and ribcage. Blood collects in the body cavity, as in a bowl, and is often lapped up, behavior which probably enables cheetahs to subsist in the desert where drinking water is scarce. After an hour or two, nothing is left of a Thomson's gazelle except the skeleton, skin, and digestive tract.

While feeding, a cheetah gives the impression of being nervous, for it continually looks over its shoulder or sits up and glances around. There is good reason for being alert. Soon after a kill has been made, vultures drop from the sky and stand around, waiting to scavenge the remains. Vultures descending steeply always indicate a source of meat, and the various predators have become adept vulture watchers. Any lions and hyenas in the vicinity race toward the spot and drive the timid cheetah from its meal. During the time I observed the female, she had two of her kills appropriated by a lion and one by a hyena.

The female cheetah was, however, an exceedingly good huntress, and the occasional loss of a kill or a miss during a hunt did not deprive her cubs of much food. In 26 days she killed 24 Thomson's gazelles and one hare. She did not capture anything on three days, although she tried, but on two days she caught two gazelles a day. I estimated that she killed 22 pounds of prey each day. Parts of each carcass are, of course, not eaten and other predators took away some kills. Yet even when this loss is considered, the female cheetah and her cubs still had 12 pounds of meat available each day—and all of it was eaten.

Conditions seem to be ideal for the cheetah in the Serengeti National Park. The open woodlands and plains provide their preferred habitat, and prey is abundant and readily caught. Yet in the 6000 square miles of the park there are only about 150 cheetahs. What keeps their numbers down? Some mammals space themselves out by setting up territories, but the cheetah does not appear to do so. Reproduction seems adequate. There are over twice as many females as males in the population and large cubs are a fairly common sight. Very little is known about the biology of cheetahs, as shown by their poor reproductive record in captivity, and research on this elegant cat is greatly needed in Africa to make certain that it does not suffer the same fate as the virtually extinct Asiatic cheetah.

by Alison Jolly

THE AVOCETS RETURN

A BIOLOGIST'S REPORT FROM ENGLAND

The European avocet is a lovely bird. In England, it is guarded, studied, cossetted—not just because of its loveliness, but because it is rare. The avocet teased the imagination of English bird lovers by leaving these shores more than a hundred years ago, then returning of its own free will to breed in a mud puddle in Suffolk.

Why all the fuss? Avocets were never in danger of extinction. For all that hundred years, colonies flourished in Holland, just across the English Channel. Avocets breed from Denmark to Iraq. They breed in Kenya on Lake Magadi, on the Zambezi floodplain of Zambia, and a few even breed near Cape Town. Some winter in Europe, but many assemble and fly south to Africa, black-and-white wings flapping, blue legs trailing behind. There, on the soda lakes of the Great Rift Valley, you may see a flock of 30,000 avocets together, reflected with a background of pink flamingos on the pale saline surface.

But the English avocets are a national pride. Like the three pairs of ospreys, guarded day and night against egg poachers, like the even more recently returned snowy owl, the avocet is worth having just because it has elected to be English. And, although the avocet's success gives hope to the owl and osprey watchers, it still needs deliberate human support and management to survive.

From the first few pairs of timid re-immigrants, the avocet colony has grown to a record 108 breeding pairs on Havergate Island and several more at nearby Minsmere. This is a success story for the Royal Society for the Protection of Birds, which manages both reserves and which dedicated Havergate uniquely to the avocet. The R.S.P.B., founded back in 1889, in protest of the then ladies' fashion for egret plumes, has since the 1950's adopted the avocet as its symbol. Thus the bird's upturned beak and sky-blue legs adorn one of Britain's most prestigious conservation organizations.

No one knows for certain why the avocets originally left. It has been suggested that drainage of their habitat, or the Victorian craze for egg collecting, contributed to their decline, but they deserted most English counties by the 1840's—before either practice could have had much effect. Many were undoubtedly shot—and avocet eggs can even be scrambled—but some other major factor may have killed the birds or driven them off. It seems likely that even then the avocet was a rare bird, living at the margin of its range. In the early 19th century, at any rate, almost no one cared.

When the avocets returned, in contrast, protection was both high-spirited and high-handed. The avocets chose an area of East Suffolk which had been extensively flooded during World War II, where the newly-created salt marsh offered habitats to many bird species. The region was apparently entirely occupied by bird-watching army officers. Lieutenant-Colonel J. K. Stanford and his brother discovered the first avocets breeding in May, 1947. At once, a dawn-to-dusk watch was organized by Captain Stuart Ogilvie, who owned Minsmere, and Major E. Lynn-Allen. With military efficiency and boy scout enthusiasm, these men, and the R.S.P.B. volunteers who followed them for two succeeding years, managed not only to protect the Minsmere and Havergate avocets from disturbance, but to keep their existence secret from the public.

At last, in 1950, after the R.S.P.B. had purchased Havergate, leased Minsmere, repaired seawalls and sluices, and built hides (blinds) for visitors' observation, the secret was revealed. C. F. Tunnicliff sketched the courtship display; Ludwig Koch recorded the voice of the avocet for the B.B.C. Phillip Brown of the R.S.P.B. made the adventure public in a delightful booklet, "Avocets in England: A Joint-Enterprise of Birds and Men." He described the courtship, nesting, and self-defense, and concluded, "At last one could feel reasonably confident of the future." Avocets, as an English species, were launched.

Last year, the avocet colonies attained majority—21 years on Minsmere and Havergate. It is even possible that these birds stay permanently in England—a wintering group on the River Tamar, in Devon, seems to fluctuate in numbers about as the summer one in Suffolk. As yet, however, they have not spread to other nesting sites. Dr. Peter Olney, the R.S.P.B. biologist who has chiefly studied them, says that in Holland they seem far less choosy of breeding ground. There they nest even in plowed fields, so long as the fields are near water; in England the avocets nest only in selected, brackish lagoons.

Peter Olney took me to see Havergate on a sunny day in August. The motor launch roared away from Orford pier, our bearded boatman squinting against the wind like an illustration from *Captains Courageous.* Havergate, however, is no sea adventure. It lies in the mouth of the River Ore, protected from the North Sea waves by the long shingle spit of Orford Ness. Fresh water pours in from the Ore and from Butley Creek; gentle tides bring salt water from the south. The brave roaring of our motorboat was drowned by fighter jets landing at the nearby NATO base, flying twinned like mating dragonflies. A ferry growled past, carrying a power shovel to build the Early Warning Missile Tracking station on Orford Ness, known locally as "that atom place." Just in case one feels oppressed by 20th century belligerence, the donjon keep of Orford Castle overlooks all Havergate as well. Built from 1165 to 1172, the

castle is far too well-preserved for misty romanticism. It was an organ of war, and if the defenders merely threw catapult balls and boiling oil, it was just that they hadn't yet thought of missiles and napalm.

We beached on the shingle, by a couple of cedar huts where Simon Corbett, the summer warden, lived. Simon with two other boys, "voluntary watchers," stood waving to greet us. He spent the summer, before starting at Oxford, camping alone on the not-so-desert island. With no boat, he was effectively cut off from the mainland, although in sight of the castle and in sound of the jets. He had, however, the supervision of Reginald Partridge, the permanent warden, an Orford man who has cared for Havergate since the first avocets were seen there. Simon also had to cope with the thrice-weekly influx of tourists, the pleasure yachtsmen who think the "NO LANDING" sign doesn't mean them, the voluntary watchers who visit a reserve for 10 days at a time under R.S.P.B. aegis—and, on quiet days, the visiting biologist. Thus, by teamwork of professionals and amateurs, salaried men and volunteers, the R.S.P.B. manages reserves, carries on research, and makes the rarities of bird life visible to the public.

We scrunched up off the beach and started down a path of springy turf. The grass on this "high" ground, Peter explained, really is very choice—including a species groundsmen plant on cricket pitches, which will endure almost anything. In earlier days the grasses also made fodder for particularly well-flavored beef, so the R.S.P.B. had to fight farming interests in claiming the land for birds.

Havergate has nearly always been a grazing marsh. Its name probably means "goat-road," derived from *hockfer* (Anglo Saxon) "he goat" and *gata* (Norse) meaning "road." Judging from old maps, at first it was brackish marsh, as today, but a disastrous storm in 1421 flooded the area, ruining the grazing along the east coast. The farmers imported Dutch engineers to build dikes, after which, for nearly 500 years, the island became fresh fields and pastures. During the war a shell hit squarely on the Havergate seawall. No one just then was concerned enough to rebuild it, so the island's flora began reverting toward the salt-loving vegetation of 1421. The seawalls, drainage channels, and the very field-furrows remain, to provide mini-differences of habitat.

We walked on dry ground, with grass and sea-beet, a neglected vegetable that Dorothy Hartley's *Food in England* lyrically likens to asparagus and mushrooms, and sea lavender, pungent where our feet brushed it. A little lower, these gave way to *Salicornia,* or marsh samphire, with green jointed lettuce-colored stems turning red later in the year. Marsh samphire is said to be edible in salad—Simon had tasted it; Peter, who thinks of *Salicornia* as stuff that dries to make avocet nests, had not. Below the samphire, again, is only bare mud, where the avocets make their nests.

We climbed a few steps to the hide (blind), a wooden hut with benches and shuttered slits, like a square-ended pillbox. Seated in a row, we lifted our wooden shutters to look down on the avocets.

No more than a mud puddle, the South Lagoon is the cradle of many avocets. Black-and-white feathers gleaming, the birds doze, on legs the color of English sky reflected in water. Juveniles, tinged with brown, waggled their bills in the water, worrying the mud at the bottom for chironomid fly larvae, or even a wriggling nereis worm. The avocet's upcurved bill does not filter food from water by means of teeth, as do those of the paddling ducks, but senses prey by touch and takes the larger worms and the fly and beetle larvae off the mud surface like a skimming spoon.

The brown-tinged juveniles are the triumphant end of the summer's breeding—167 raised to fledging, past the hazards of the nest phase.

The adults arrive in April, or even late March, apparently already paired. Courtship display begins shortly after arrival. It starts as both birds feed and preen with, as the R.S.P.B.'s Brown says, increasingly "self-conscious" gestures. Then, suddenly, the female lays her chin and beak along the water surface, while the male continues preening. He advances toward her and splashes water over both of them with his bill, then steps quickly behind her to the other side, to splash again. The side-to-side movement may be repeated 20 times before he mounts and mates with her, black-tipped wings raised high. Then, as a final display, the pair briefly cross their upturned bills, the male's wing over the female's back, before they separate.

Later, one or both birds may walk along the muddy shore, apparently—or perhaps really— flicking bits of material into the air with their bills. Suddenly one pitches forward on its breast, wings drooped, feet scraping backward behind. This unlikely action marks the first choice of a nest site. Over one to three days, one such "scrape" becomes preferred. The parent birds may place in it only a few twigs of dry marsh samphire, laying nearly on the bare mud, or amass a fairly substantial little haystack of loose ends.

The female lays three to four buffy eggs, speckled with grey or brown. The eggs are incubated almost continuously for 22 to 24 days from the completion of the clutch. One parent relieves the other at the nest. The sitting bird does not rise until its mate, approaching slowly and deliberately, is only a few yards away. Then the sitter

The European (and once again English) avocet is a long-legged wading bird with black-and-white plumage and an upcurved bill.

stands up and minces away, tossing its head back over its shoulder toward the nest, as it did when tossing mock material in choosing a nest site.

Finally the chicks hatch, downy and vulnerable. They can swim and run and forage for themselves. But now they risk straying into the territories of neighboring avocets, who may pick up a strange chick and shake it until it dies. Many predators attack undefended chicks (while the R.S.P.B. wages war against the predators). As soon as the chicks hatch, the parent birds become far more excitable, flying up to harry any passing bird or human. At the start of their distraction display they whirl about, "kleeping," and dive-bomb the intruder. If these antics fail, the parent bird flounders along the ground, wings trailing, and often ends up in a lagoon.

At last the young grow true feathers and come to resemble their parents, and the flocks disperse up and down the coast. Havergate becomes simply a favored, mucky, foraging area of fruitful mud.

Peter, over a fine English outdoor lunch of pork pies and sweet buns, talked about the endless problems of avocet management. The sheer physical environment is the first thing. Now that the avocets have reached an all-time high, they may be limited by available space. As an avocet will kill a strange chick on its nesting territory, and the lagoons seem to be quite fully partitioned out between the birds, the R.S.P.B. is trying to make

Havergate's middle lagoon into an acceptable nesting as well as foraging area with new drainage and sluices.

Peter's own research has mainly centered on diet. The breeding success per pair has varied considerably since 1947, but began to show a steady decrease from 1957 onward. One possible factor was the change in available food supply, possibly correlated with changes in the salinity. Earlier policy had been to "lay on" water in spring, by closing the sluices during the spring rains. This forced the birds to nest on high ground, out of reach of later floods. Then the sluices were opened, revealing an expanse of bare mud for foraging. Tides were also let in during the winter. This policy and the shallowness of the water led, however, to drastic changes in salinity, so much so that few invertebrate species could survive the extreme fluctuations. As a result of Peter's work, they are now attempting to keep the salinity more constant and encourage a richer fauna in the mud.

It is, incidentally, amazing that anything can love that mud. Under the top few inches, it turns black and de-oxygenated, with the rotten-egg stink of hydrogen sulphide. Waterlogged all the way through, if a man takes a wrong step it engulfs him thigh-deep. At least the mere threat keeps tourists to the paths and away from breeding birds—but once Peter, after a day's "biologizing," forgot how he smelled and walked into a crowded restaurant, only to be reminded of his pungent scent by the customers.

The predators are easier to see, but not easier to discourage. In the early days, Reg Partridge, the warden, found nest after precious nest raided by rats. Warfarin soon took care of the rats, but then a colony of black-headed gulls built up on the higher ground. Gulls took so many chicks and eggs that the avocets' breeding success dwindled from 3.0 fledged young per pair in 1952 to 0.3 in 1962. In 1962 a mere 20 chicks survived to fledging. One attempt after another failed to control the gulls, until the warden began pricking eggs and raking over nests, which soon discouraged the adult gulls from returning. Now the gull colony is down from 5000 to 500 pairs. This was a break for the Sandwich terns as well, for many gulls robbed home-coming terns of their little sand-eels, so that tern chicks actually starved.

Get rid of one predator and another appears: stoats, which used to hunt over the island apparently feeding on the gull and tern colonies, now make more obvious raids on avocet young. Stoat-trapping-and-removal became one of Simon's regular summer duties. Peter wryly told of leaving the island by boat one day as a stoat swam past him in the other direction, bound for its small pirate feast.

"Of course," qualified Peter, "all this is a question of relative values. Here we are just protecting avocets. I can well imagine some people, or other situations, in which you would prefer a few stoats, or even 5,000 black-headed gulls, to the avocets."

At last we reached the North Lagoon and settled in our pillbox. Afternoon sun bloomed red on the tufts of *Salicornia* growing where once the fields had been. The field lines showed through here, the bones of the lagoon, an old cattle gate hanging by one hinge across a ditch of blue water. Behind all, across the estuary, Orford Castle gleamed with contained sunlight. As usual, England looked awash with damp—like a watercolor—greens and blues blurring together, leaving only the red samphire and the golden castle with colors of their own. You could almost see it as a classic English landscape except that avocets picked the furrows as crows do a field, gobbling sea-worms instead of seed and corn.

"Look," said Peter. "Look at that short-eared owl. There are four nests on Havergate now, and they could well become the next avocet predator. Then we'll have a real dilemma of conscience." The owl dropped into the grass, perhaps aiming at some small rodent, then flew again, gliding right toward our hide. The sun gleamed on its tawny feathers, and its face was a stylized mask of a white X'd "nose-piece," deep brown eye-patches, and luminous yellow eyes. It flew with its owl-face straight forward, like a shark, or the painted face of a war-time bomber, uncanny as the masks of African Makishi dancers which twist straight up to the sky while the human inside the costume peers out through the mesh of the "god's" neck.

"You wouldn't destroy that owl!"

"No, of course not," said Peter. "But if their numbers grow, we might have to transplant some to the mainland. The point is that we manage Havergate—so it would be our decision."

Is Havergate worth it? Supporting Havergate, whatever the cost in money and time, is its own reward. The worth of the precious few English avocets is precisely the worth of the care put into them, the delight they give in return.

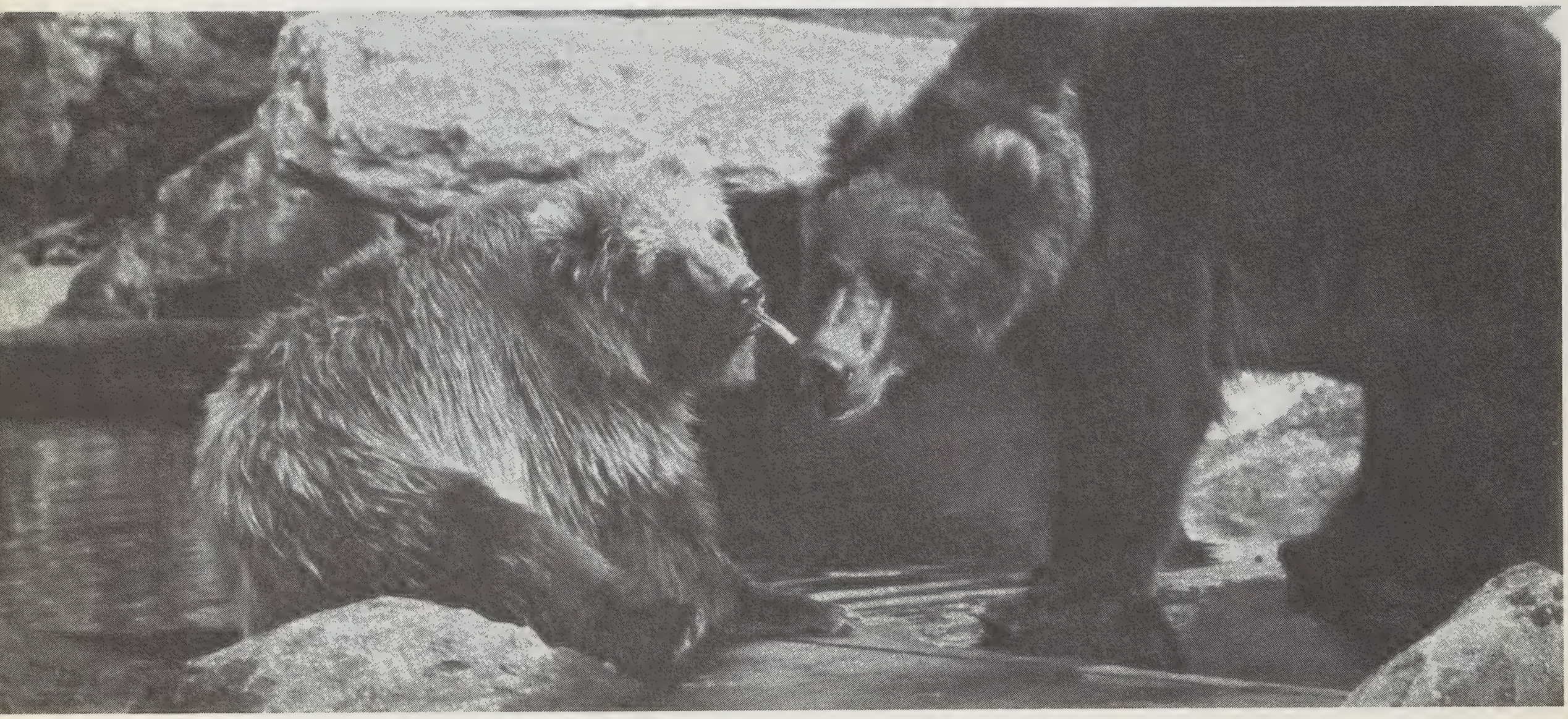
Is it natural? No, but what is natural? Havergate before the bird preserve, with green fields and fences? Havergate, five hundred years ago, before the dike-builders came from Holland? Or before the Anglo-Saxon road for goats? Before the Early Warning System, or the grim golden castle?

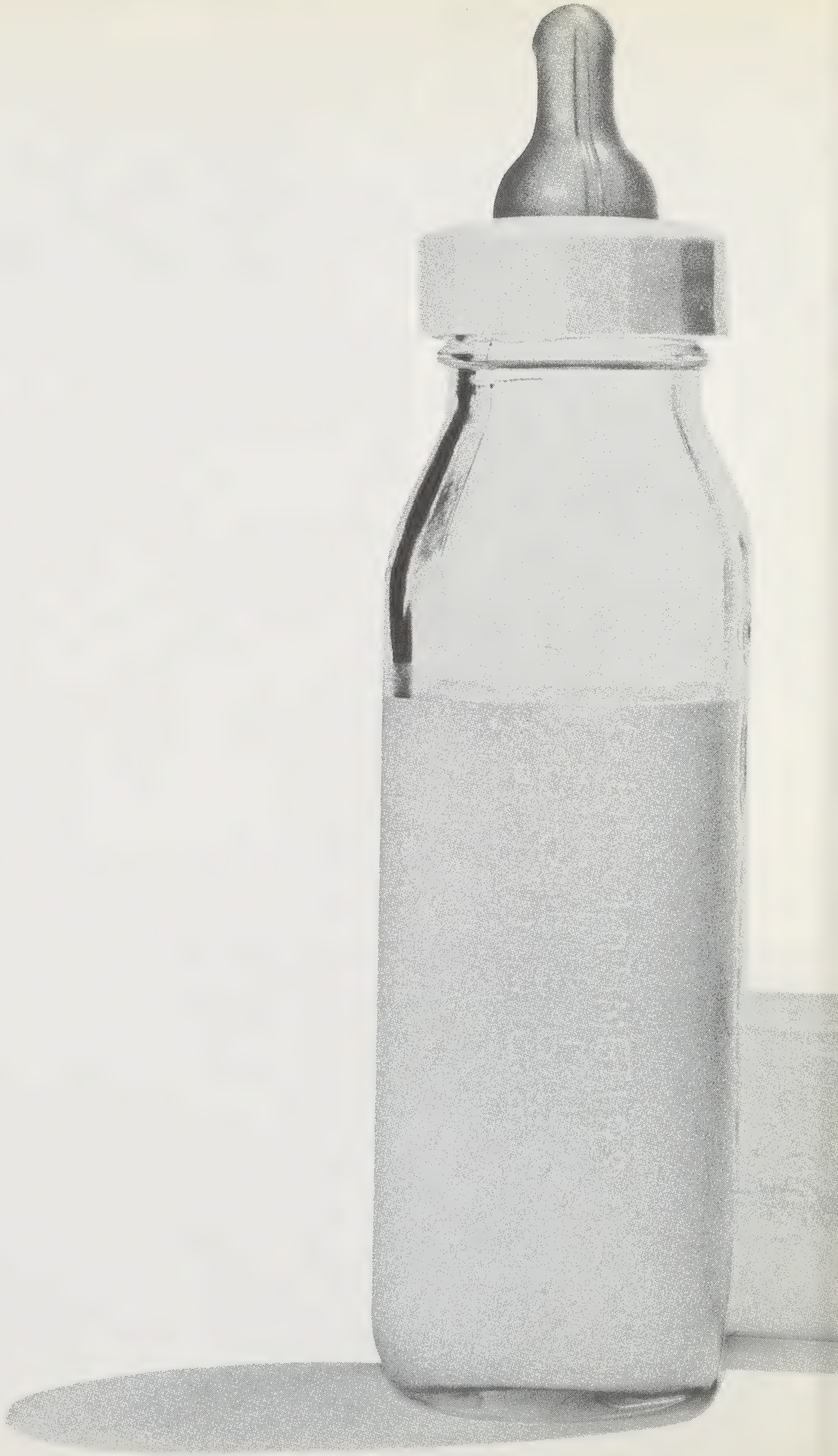
A price which England pays for the richness of her history is the relative poverty of wilderness. If every foot of English soil has been plowed, tended, loved, and even died for, surely a few acres can be set aside, and planned, and managed, for one lovely English bird—the avocet.

BEARS

KODIAK BEARS AND POLAR BEARS AT THE BRONX ZOO

PHOTOGRAPHS BY EMMY HAAS





BY GERALD S. LENTZ

BOTTLE BABIES

Hand-Raised Hoofed Animals at the Oklahoma City Zoo

I lay motionless on an asphalt roof under the late summer sun and waited for a blackbuck antelope to wander into range of my injection gun. I had spent the better part of three days on that roof overlooking our blackbuck pen waiting for the shot that would rapidly immobilize my quarry, a young male. He was a yearling that had been born and raised in the pen—a typical blackbuck, alert and flighty. The longer I remained on that roof, the more certain I became that there had to be a better way to remove surplus hoofed animals, blackbuck in particular, from our zoo.

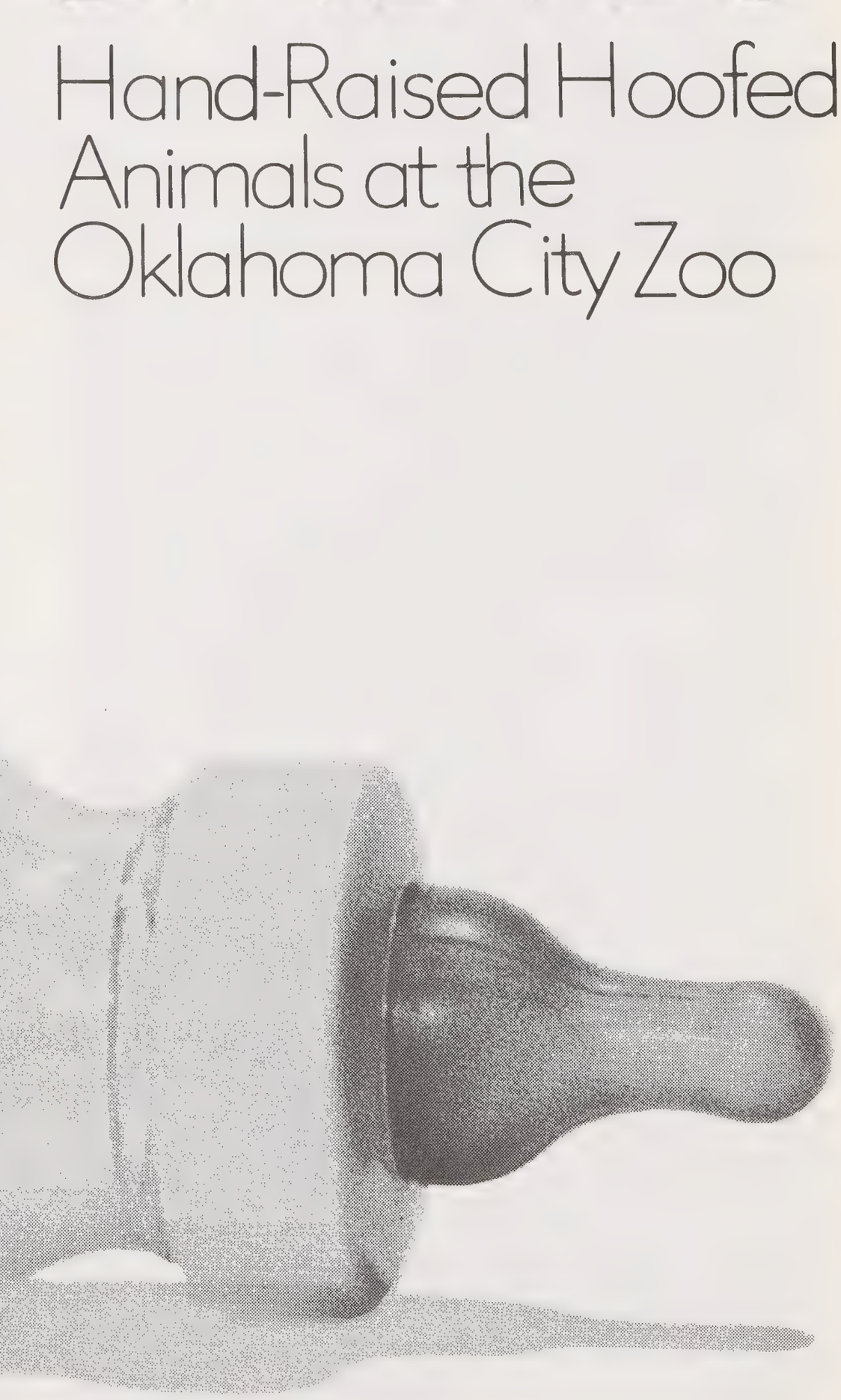
The hoofed animal area at the Oklahoma City Zoo sprawls over some 40 acres of rolling land and is divided into 26 major pens, which vary in size from three-quarters of an acre to more than three acres. African buffalo and antelope, Asiatic cattle and deer, mountain goats and sheep, and North American hoofed animals inhabit the exhibits.

Each pen is large by zoo standards and is ideal for the animals because of freedom for movement and seclusion, but these same pens present problems when individual animals must be handled for any reason. Although each pen has a shelter, only the giraffes are routinely closed inside it; the other animals are free to come and go at will. This results in an extremely difficult situation when it becomes necessary to capture an animal. Animals destined for shipment must be removed as quickly as possible from their pens, with minimum stress for them and their pen-mates.

Added to the problem of handling surplus animals was the danger of losing winter-born babies to exposure. We decided that we should be able to solve both problems effectively by bottle-raising in our heated nurseries surplus stock and young born in inclement weather.

The first problem that confronted us was determining how soon a baby should be removed from its mother. Young hoofed animals taken from the mother after two or more days are extremely reluctant to accept a bottle. If a young animal is taken from the mother immediately after birth, however, the youngster has no opportunity to nurse and thereby receive the various antibodies that are present in the colostrum, or "first milk." These antibodies aid the young animal in building immunity to various ailments. With this fact in mind, we decided to leave newborn animals with their mothers for 24 hours.

After the youngster is taken from its mother, it must be acclimated to a totally different environment, a fact we learned in an unfortunate way. The first hoofed animals that we attempted to raise on the bottle were blackbuck, a notoriously excitable species from India. Three blackbuck, born within a few days of each other, were brought to the nursery and housed in a room at



the far end of the building where there was virtually no commotion. We made every effort to create as little disturbance as possible around the young antelope and only entered their room to feed and to clean. The animals remained excitable, however, and very little progress was made in working with them. As a result, two of the animals died from starvation.

In desperation, we tried what we considered to be a radical step and moved the surviving young blackbuck into the nursery kitchen where it was literally under the feet of the nursery personnel. Within a short time it calmed down and even began following the nursery attendants about the room; then it began feeding, and subsequently survived. By trial and error, we had discovered the answer to acclimating the newborn animals to their new surroundings: expose them immediately to people and normal noise. Since then our procedure has been the same with all baby animals except Cape buffalo, simply because of their size and destructive habits.

The beginning diet for the young ruminants is simply whole cow's milk. As the babies grow, their diet is altered to meet their needs. The responsibility of feeding and caring for the immature animals lies in the hands of our nursery staff, which consists of a supervisor and a keeper, both young women, who are human "mothers" to these baby hoofed animals.

Occasionally the nursery receives youngsters that refuse all attempts and techniques to bottle-feed them. At times like these, domestic milk goats are used as foster mothers. Normally the goats must be restrained when new babies begin nursing, but within a few days they usually accept the strange offspring and care for them as if they were their own.

Various techniques are used on new arrivals when introducing them to the bottle. The method used on our first Cape buffalo, Tinkerbell, provided some lighter moments. She entered the world as 80 pounds of clumsy confusion. She was friendly and hungry from the beginning but had more difficulty learning to nurse than any other animal that we have raised. She constantly rooted and nudged her keeper in her search for the nipple; however, Tinkerbell learned to nurse only after the keeper held the bottle behind her own back with her right hand and exposed the nipple between her left arm and waist, whereupon the Cape buffalo eagerly drained the bottle. Shortly thereafter, Tinkerbell learned to use a bucket designed for feeding domestic calves.

Tinkerbell progressed rapidly, remained painfully friendly, and when five months old was returned to a pen near the enclosure of her birth. At a year-and-a-half, she was large enough to put back with her parents. Today Tinkerbell is a robust two-and-a-half-year-old.

Another "problem child" was Yancy, a male nyala antelope. Yancy presented no feeding problems as an infant but did present a few minor headaches as he grew older. Yancy was so docile he was kept in the nursery for more than a year as a calming influence on the other nursery residents. The only problem with Yancy was his eagerness for the bottle. When the younger animals were given their bottles, Yancy, a nearly full-grown nyala, wanted one too. If he was not offered milk, Yancy made such a nuisance of himself that a bottle was usually forthcoming so the nursery "mothers" could proceed with other tasks.

The blackbuck and addax, another species of antelope, are the two most common inhabitants of our nursery. Both exist in nature only in small numbers. The blackbuck inhabits grassy plains in India and rivals the cheetah for speed. It has been eliminated from much of its former natural range, but is very common in zoos and as introduced game on ranches. The addax, a native of North Africa, inhabits desert country and is exceedingly rare in both nature and captivity. Severely overhunted, its survival in nature is doubtful. In the light of these facts, the breeding of these animals in captivity takes on added importance.

The animal nursery at the Oklahoma City Zoo is a busy place at feeding time (above). A frequent nursery inhabitant is the addax (shown as adults at upper left, opposite), a desert animal with broad flat hooves adapted for the soft footing of its native Sahara. The blackbuck (shown at right and below), although an extremely high-strung animal, is among the more commonly exhibited antelopes in zoological collections, principally because of its hardiness; only the males have the handsome spiraled horns.

The gemsbok, largest of the oryx antelope and native to the open, arid areas of southwestern Africa, is another of the hoofed animals hand-raised at the Oklahoma City Zoo.

Nineteen blackbuck have been raised in the nursery. Naturally, this antelope is the best known to us and most predictable. Almost without exception, we can depend on a rather nervous nursery whenever a blackbuck is being raised. Even though the blackbuck obviously "tames down" tremendously in the nursery, it is still an extremely high-strung animal and is liable to take flight at the slightest break in routine. Its nervousness influences the other nursery babies similarly and has caused mild chaos in the past, fortunately not resulting in serious injuries. It is interesting to note that a blackbuck's presence in the nursery will result in an overall unstable group of animals, but if the blackbuck is removed, within a day or two the remaining animals become relaxed and unaffected by minor breaks in routine.

Even though excitable, the blackbuck adjusts with relative ease to the bottle, while the addax antelope has been as stubborn as the proverbial mule. Our adult addax are docile animals, very rarely disturbed by things that upset most antelope. The young, when hand-raised, are even more pleasant and stable. Therefore, it has baffled us completely to encounter so much difficulty encouraging newborn addax to accept a bottle. Most of the nine addax that have been hand-raised in the nursery have had to be raised by milk goats. This is for me another one of those unknown quantities that make zoo work so interesting.

Our bottle-raised hoofed animals are far easier to handle than their semi-wild parents. Crating hand-raised individuals is a sight to behold. Instead of the frightened, jumpy animal that stands a chance of injury during crating, we have a tame animal that remains calm. We have even had some hand-raised animals that were backed into crates while nursing a bottle and which continued to nurse through openings in the crates after the doors were shut.

Another advantage to tame animals is the relative ease with which they may be treated medically. Some individuals raised in the nursery are returned to their parents in the large display pens after reaching an age and size that will allow the young to be accepted by the adults. A recent medical case concerned one of these animals, a female Grant's gazelle named Beauty. Beauty was born January 21, 1968, and raised in the nursery. In May, she was re-introduced to the adult Grant's gazelle group and was accepted without problem. Near the end of June, she broke her right front foreleg, which we suspect was the result of an encounter with a wild gray fox that had been raiding our bird population and three days before had been seen chasing a young Cape hartebeest.

Since Beauty had returned to the pen of her birth, she had become attached to all of her keepers, one in particular. That morning, even with a broken leg, she allowed him to pet her and gently move her into a barn. When our veterinarian arrived, five of us entered the barn and gently restrained her. A mild sedative was administered and a splint applied, all without struggle and without subjecting the animal to added stress.

Beauty even allowed periodic inspections of her cast until it was removed, and her recovery was uneventful. Today she is a beautiful year-old animal and also, apparently, an expectant mother.

Eighty-four hoofed animals representing 23 species have been raised in the nursery since December 1965. During this three year period, only 10 animals, representing four species, have failed to survive.

Two hazards facing hoofed animals in our zoo have been greatly reduced. By decreasing the risk involved in crating, and increasing the opportunity of diagnosing and treating illness, we have increased the life expectancy of these animals. Greater longevity results in an added reproductive potential. With deaths less frequent and more young produced, conservation of wildlife can be effectively aided in a zoo. Creation and maintenance of large captive herds of hoofed animals in zoos can virtually eliminate the need for acquiring animals from wild populations, already severely depleted; and this sort of conservation effort is, after all, a major zoo responsibility.

INSECT IQ

by Edward Edelson

RESEARCHERS STUDY THEM IN SEARCH OF A NATURAL PESTICIDE

How do you kill an insect pest? The answer to this question is simple if it's a single pest: hit it with a swatter. If a larger number of insects must be disposed of, spray them with a toxic chemical. In recent years, the second solution has been used on an ever-increasing scale. In 1967, for instance, more than a quarter-of-a-billion dollars was spent on chemical insecticides.

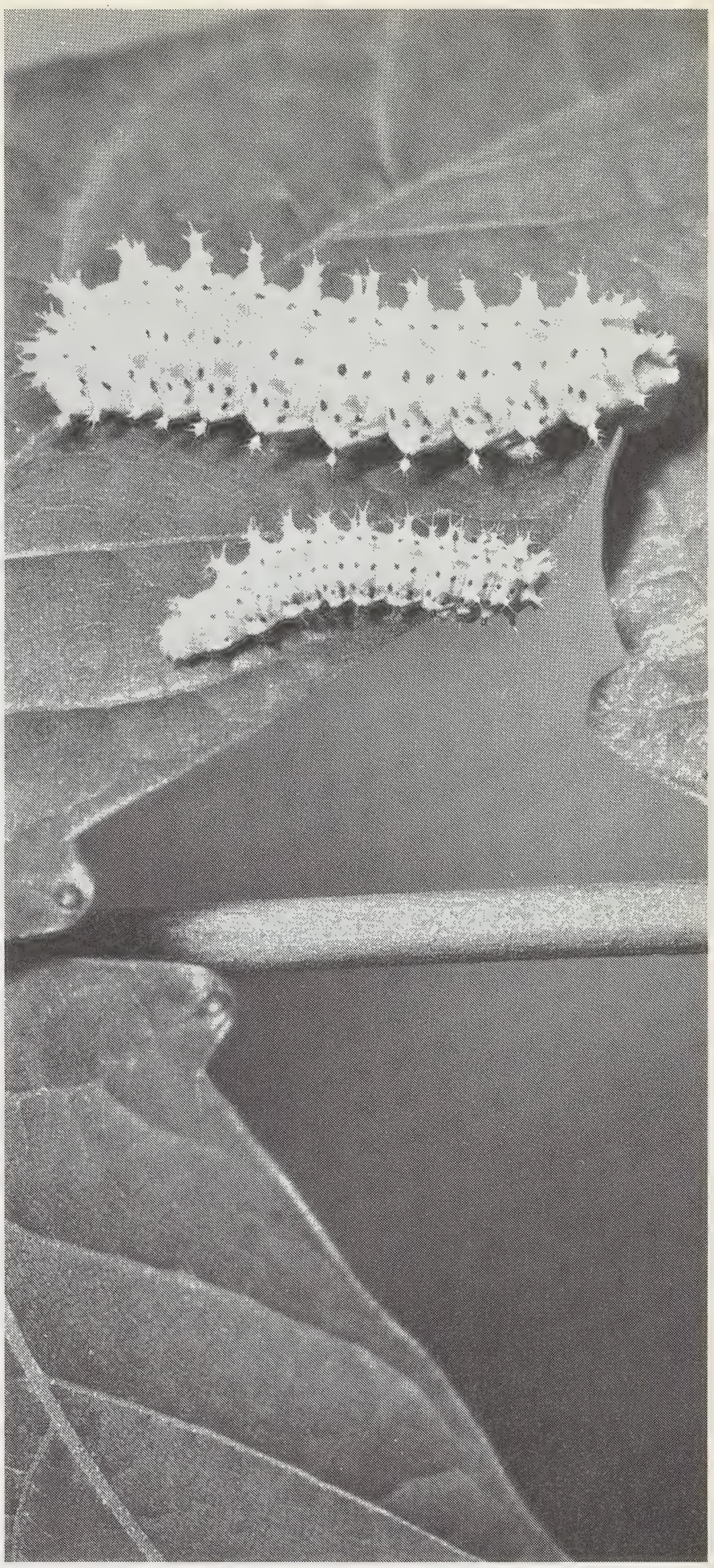
The results achieved by this widespread use of chemicals have often been spectacular. Chemicals so efficiently dispose of harmful insects they are the major anti-pest device of farmers and health authorities. The modern era of chemical pesticides, now 25 years old, started with the discovery of DDT. However, the drawbacks of these weapons against insects are becoming increasingly apparent.

Chemical pesticides kill with depressing thoroughness. But they kill helpful and harmless insects as well as pests and, since many pesticides are long-lasting – DDT's chemical half-life is 15 years – they tend to permeate natural food chains and have harmful effects on other animals, perhaps even on man. The problem was first brought to national attention by Rachel Carson, a New York Zoological Society gold medalist, in her 1962 book, *Silent Spring,* and has not abated since.

In addition, these poisons appear to lose their effectiveness with time. When an insecticide is first used it kills most insects exposed to it. The survivors are individuals resistant to the chemical because of their genetic makeup. They survive to breed, and due to the rapid rate of insect reproduction and great number of eggs most insects produce, populations of resistant strains build up quickly. For example, resistant strains of *Anopheles* mosquito have developed and in recent years have seriously hampered malaria eradication programs. Similarly, efforts to fight the spread of plague among war refugees in Vietnam have been crippled because the fleas that carry the disease are resistant to pesticides.

So the original question must be posed differently: How do you kill the insect that is harmful to man *without* disturbing nature's balance and *with* a weapon that will not become useless after a few years?

Nature itself offers a possible answer and increasingly scientific interest is being focused on the biological control of insect pests. One of the most promising of these approaches involves attempts to eliminate insects by disrupting their normal growth and development. After emerging from the egg, most higher insects begin life in a larval stage, usually considerably different in form from that of the adult. The caterpillar, for instance, gives little evidence of becoming the butterfly, and there is no seeming connection between the legless, wingless maggot and the future fly that is its adult stage.



The further development of these Cynthia caterpillars will be determined by the presence or absence of the juvenile hormone.

The changes in shape a developing insect undergoes (the entire process is called "metamorphosis") are triggered largely by hormones, chemical "messengers" that stimulate physiological activity. The transformation of, for instance, a caterpillar to a butterfly occurs during a pupal, or resting, stage. The caterpillar spins a cocoon; when the transformation is complete, the pupa's covering opens, and the adult emerges.

Various lower insects do not undergo metamorphosis, while others experience metamorphosis that is incomplete. Grasshoppers and locusts, for example, emerge from the egg with a form that heralds the overall shape of the adult. They go through a series of molts, experience various slight

changes in body form, and the addition of certain structures, but develop into the adult without any striking morphological change.

Complete metamorphosis, on the other hand, can be a dazzling display of nature's capabilities; the transformation of a caterpillar into a moth or butterfly has fascinated naturalists for centuries. Yet only in recent years have details of this process become known. It is this knowledge that may have opened the way to new methods of controlling insect pests.

Until about three decades ago, almost nothing at all was known about the internal mechanisms that controlled this change. Then, in the 1930's, a series of experiments by Vincent B. Wigglesworth with *Rhodnius prolixus,* a South American bug, solved many of the mysteries. Wigglesworth's work was extended in a series of elegant experiments by Dr. Carroll M. Williams at Harvard University.

Working with the Cecropia moth, Dr. Williams cut pupae in half. Invariably, the front half developed to the adult form, while the hind part failed to develop. Clearly, the substance that controlled metamorphosis was produced in the front half.

Dr. Williams then tied off the Cecropia caterpillar's head from its thorax—and prevented metamorphosis completely. This meant that whatever was produced by the head merely began the process. The substance had to reach the thorax to trigger production of a second chemical, which then traveled all over the body to cause metamorphosis.

Further experiments showed that three different hormones were involved in the Cecropia moth's growth and development. One, called brain hormone, is produced by a small group of cells in the insect's brain. When the brain hormone is produced, it travels to the thorax and stimulates another group of cells, called the prothoracic glands, to produce a hormone called ecdysone. It is ecdysone that causes both the successive molts of the larva and the metamorphosis of larva into adult.

A third hormone determines which—molt or metamorphosis—takes place. If this hormone is present, the larva molts and remains a larva; if the hormone is absent, the insect metamorphoses into its adult form. For this reason, the hormone is called the juvenile hormone. It is this chemical that now offers a new method of attack against harmful insects.

Its great promise is selective action of a kind not now available. There are indications that juvenile hormone differs significantly in different species, so that it may be possible to use the hormone against pests without harming innocuous species. And while conventional pesticides kill by deranging nerve activity—which has the same basic mechanism in both insects and vertebrates—juvenile hormone does not harm vertebrates because of their obviously uninsectlike development. But it plays a vital role in many phases of the insect's life.

Juvenile hormone is produced by the corpora allata, two small glands in the insect's head. It has profound effects on the insect's development, some of which are just coming into view. For example, biologists at Harvard have found that insect eggs will not develop normally unless juvenile hormone is absent.

Thus, the hormone itself offers promise as an insecticide. If pupae are exposed to it at the critical period of metamorphosis, they fail to develop into adults and do not reproduce. The juvenile hormone is more powerful in this role than any known insecticide. A University of Wisconsin scientific team, which isolated and identified the hormone, found that a single gram could destroy one billion insects.

But use of the juvenile hormone as an insecticide is not that simple. One basic problem is getting a sufficient amount to work with. The hormone has been extracted only from the Cecropia moth and a close relative, the Cynthia moth. The Wisconsin scientists, who isolated the hormone from oil taken from tens of thousands of these insects, found that it was a molecule which as yet has not been synthesized.

Scientists in other laboratories have been working on chemicals with similar structures in the hopes of finding some with juvenile hormone activity. One such substance was produced by Dr. John H. Law, now at the University of Chicago, by the simple process of bubbling hydrogen chloride through farnesenic acid, which is chemically related to the juvenile hormone.

The substance produced by this method turned out to have six active ingredients, only one of which has been isolated at this writing. But a more recent development indicates that other such substances are available from nature. The discovery also indicates that other living things might already be using chemicals with juvenile hormone activity as pesticides.

The trail that led to the discovery began when Dr. Williams began working at Harvard with Dr. Karel Slama, a Czech biologist, on a European true bug, *Pyrrhocois apterus.*

Dr. Slama had bred several generations of the bug in his Prague laboratory for a decade. In the laboratory at Harvard, however, the bugs could not be raised normally. They either remained larvae through successive molts or became strange adult-like forms with larval characteristics. The only explanation was that the bugs somehow were

coming into contact with juvenile hormone. But where did it come from?

The source, it developed, was the paper toweling used in the jars that contained the insects. Newsprint, magazine paper—almost any paper made in the United States, in fact—had the same effect, while paper from Europe and Japan did not. Investigation led to the balsam fir, the major source of paper pulp in Canada and the northern United States, as the source of the juvenile hormone activity.

To track down the precise chemical responsible, the Harvard scientists turned to Dr. W. S. Bowers of the Department of Agriculture laboratories in Beltsville, Maryland. Dr. Bowers, a leading expert on insect hormones—he and his colleagues already had produced a chemical with juvenile hormone activity—found that the "paper factor" was a chemical produced by the balsam fir with a close resemblance to the juvenile hormone.

But why should the balsam fir produce a chemical that protects it against an insect that does not attack balsam firs? Scientists can only speculate on the answer. "The most intriguing possibility is that the paper factor is a biochemical memento of the juvenile hormone of a former natural enemy of the tree—a pyrrhocorid predator that, for obvious reasons, is either extinct or has learned to avoid the balsam fir," Dr. Williams said.

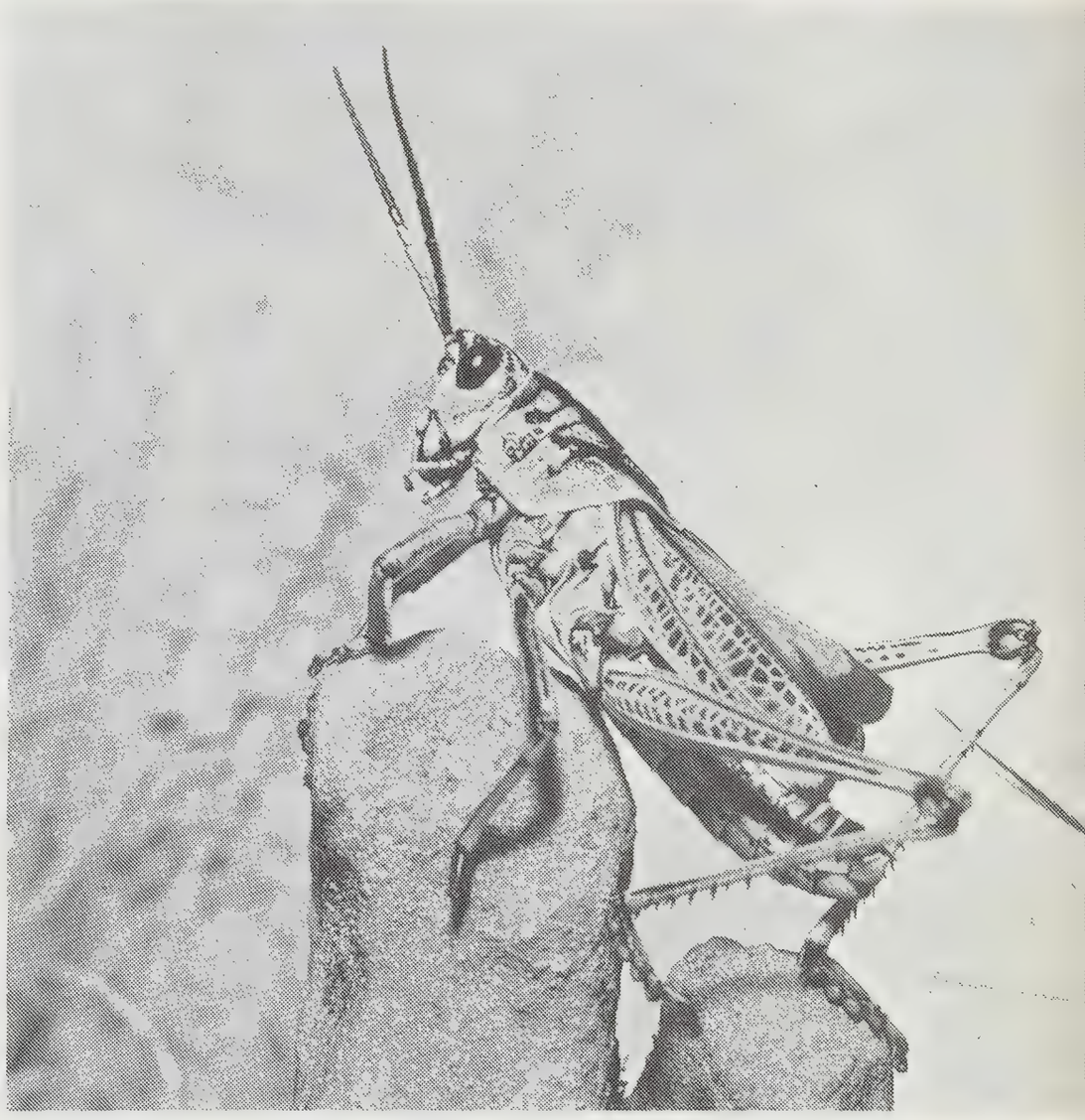
The evergreens as a group might be a fruitful source of other chemicals with juvenile hormone activity, Dr. Williams believes. He points out that the evergreens preceded the insects on earth and do not rely on insects for fertilization, thus having every reason to develop defenses against insects. Thousands of chemicals similar to the paper factor are produced by the evergreens, and some of them might have similar activity.

Some commercial interest already has been aroused in research-oriented companies. So many requests have been received by Dr. Bowers for samples of the hormone-like material he synthesized that arrangements were made for production of a small batch by a commercial laboratory.

Dr. Bowers has found that the chemical might have a direct use in fighting two harmful insects. He discovered that it disturbs the diapause—the insect version of hibernation—of the cereal leaf beetle and the alfalfa weevil. If those insects could be awakened from the diapause at the wrong time of the year, nature itself might dispose of them.

Hormones are not the only natural substances being investigated as a possible weapon against insects. Scientists are also working with the chemicals that insects use to attract members of their own species; it is hoped that man could use the same substances to lure the pests to destruction.

Dr. Wendell E. Burkholder of the University of Wisconsin, working with other scientists there and at the Stanford Research Institute, has isolated and synthesized the sex attractant of the black carpet beetle, an insect that damages woolen clothes, grains, and dried milk. Scientists at the University of California at Berkeley have isolated the attractant used by the male bark beetle. In nature, the male beetles burrow into the bark of pine trees, leaving a chemical trail behind so the females can find them. It might be possible to use the attractant to lure the beetles into traps, where they could be killed or sterilized by radiation. The sterilized individuals could then be released to mate with natural populations of their own species. No young would result from the mating and eventually, if enough of the sterilized insects are introduced, the population of the species withers.



Insects such as this Eastern lubber locust increase in size by a series of molts; after a sudden surge of growth, the insect sheds its old shell, allowing the new external skeleton to expand.

This technique has been used successfully in controlling the screwworm fly, which once caused an estimated $20-million a year in livestock damage in the southeastern United States. The female deposits eggs in open wounds of livestock and the larvae that hatch burrow deep into the flesh. Screwworm larvae – they look like wood screws – can dispatch a steer in about a week.

Billions of irradiated male screwworm flies were released in the southern United States early in this decade. (The effectiveness of the technique had been previously tested with the screwworm fly on Curacao.) The results of the irradiation program were dramatic and the screwworm fly is no longer a major pest in the south.

Dr. George B. Craig at the University of Notre Dame has discovered a chemical used by mosquitoes as a "birth control device." In many species

of mosquitoes, females mate only once. As the male impregnates the female, he deposits a substance that prevents future fertilization. If a method could be found of exposing large numbers of female mosquitoes to this substance, the cool summer evenings could be rid of the painful slap of hand against flesh.

An even more ingenious method of fighting mosquitoes is now being used against disease-causing species in Burma. The World Health Organization has taken male mosquitoes from a species found in Fresno, California, bred them in Germany, and set them free in Burma. The females of the Burmese species can mate with males of the American species, but the eggs produced by the mating are infertile.

All of these efforts share one common goal. Man, by his sheer numbers and the power of his technology, has been damaging the planet he inhabits to an unprecedented extent. Biological control of harmful insects promises a way of regulating the environment without destroying it.

An Indian silk moth leaves its cocoon behind after undergoing complete metamorphosis.

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

The American alligator *(Alligator mississippiensis)*, threatened with extinction, has found new allies in its fight for survival against poachers and the illegal market in its hide.

American Alligator Roundup

Bathed in the glare of television floodlights at New York City's Overseas Press Club, a mayoralty candidate gingerly patted the head of a young American alligator and urged local legislation to ban sales of alligator products. Meeting in a Florida hamlet known to shelter numerous gator poachers, a group of conservationists announced the formal naming of the American Alligator Council, a national group dedicated to preservation of the threatened reptile. Only a few days before, the Secretary of the Interior had voyaged into the Everglades National Park and, in what shivering Floridians vowed was unseasonably chilly weather, had promised federal action to insure the alligator's survival.

During the past several weeks the American alligator – whose survival as a wild species is seriously threatened – has been the center of a gush of concern from likely – and unlikely – quarters.

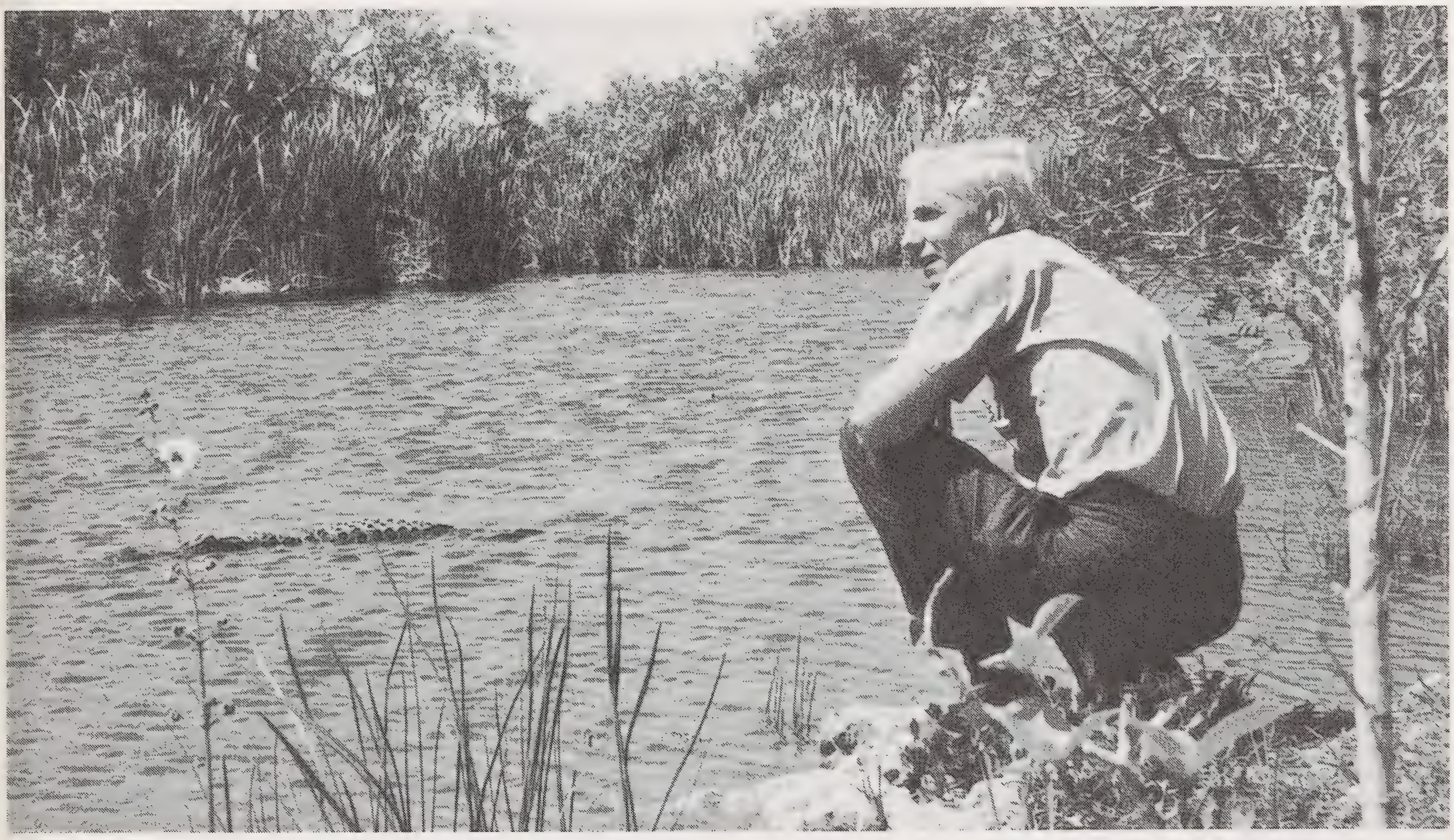
How much effect the mushrooming outcry will have on the gator's survival remains to be seen but prospects are beginning to brighten.

Certainly the fact that Secretary of the Interior Walter J. Hickel has focused on the plight of the alligator has bouyed hopes of conservationists who not long ago viewed the alligator situation with exceeding gloom. Hoping to see alligators and catch a poacher, Secretary Hickel in March toured the western area of Everglades National Park with Florida's Governor Claude R. Kirk, Jr., other public officials, and Richard Stokes, the park's assistant chief ranger.

Neither gator nor poacher was seen on the well-publicized trip but the aftermath of the trip was considerably more encouraging. Ranger Stokes, at the meeting of the American Alligator Council on March 22, reported that $100,000 in additional federal funds have been made available for employment of eight additional men and new equipment to patrol the park against poachers. Mr. Stokes said the increase in his unit's muscle will have considerable effect in curbing the depredations of poachers in the park.

The park ranger spoke as the American Alligator Council met in Everglades City, Florida, at the edge of the western water gateway to the Everglades.

With Mr. Stokes in the lead, many of the council members trekked to the park's Shark River Valley area to view what the ranger calls the "largest remaining population of wild alligators in the world." The largest alligator seen was an



Richard Stokes, assistant chief ranger, led members of the American Alligator Council into Everglades National Park in March to view the largest remaining population of wild alligators in the world (one of which can be seen swimming at left.)

11-footer, floating in a large pond by the side of a park road.

The Alligator Council is a relatively informal organization whose members represent several scientific, educational, and service institutions including the Florida Audubon Society, the New York Zoological Society, Florida State University, and the Florida Game and Fresh Water Fish Commission.

The council voiced its support of five bills designed in one way or another to preserve the alligator now pending in the Florida State Legislature.

The bills variously provide for stiffer penalties for poachers, a ban on sales of alligator products in the state, and support for the proposed federal endangered species bill, which would end interstate shipment of gator products.

Since the bulk of gator hide traffic is routed to New York City, a bill introduced in the City Council by Councilman Robert A. Low, then a candidate for the Democratic mayoral nomination, has attracted national interest. It would stop sales of products made of alligator hide in New York City, thereby putting a major crimp in the market. The bill is pending as this issue goes to press.

Low announced his plans to introduce the bill at a March 14 press conference called by the National Audubon Society. At the conference, Dr. F. Wayne King, the Bronx Zoo's curator of herpetology, provided technical information about the alligator, using a small live specimen from the zoo's collection to illustrate various points.

Among the other developments that brought cheer to those worried about the fate of the alligator was the announcement by the Florida Turnpike Authority March 21 that the once-flourishing sale of crocodilian products in the authority's roadside citrus shops would be ended.

Woodland Park Opens Tropical House

Seattle, Washington – A new Tropical House for the exhibition of reptiles and amphibians opened at Woodland Park Zoo on February 7, and, according to Director Frank Vincenzi, has already proven itself to be one of the most popular attractions at the zoo.

Some 150 individual animals are exhibited, many in habitat displays, such as one featuring alligators, tortoises, and iguanas in a planted tropical setting with tanagers flying overhead.

Animal Kingdom plans to have a more detailed report of the new Tropical House in a future issue.

Philadelphia Zoo to Build New Reptile House

Philadelphia, Pa. – Seventeen crocodiles and alligators, as well as the other inhabitants of the Reptile House at the Philadelphia Zoo, were moved from the building on April 15 in preparation for construction of a new reptile house. The present building, which will be demolished, has been in service since the zoo opened to the public on July 1, 1874.

During construction of the new building, scheduled for completion in 1971, a small but representative group of reptiles will be on exhibit in the Elephant House.

Brooklyn, N. Y. – Two blackfooted penguin chicks have been hatched by their parents in the penguin exhibit at the New York Aquarium at Coney Island. As shown above, the chick in the foreground, at about seven weeks, shows partial feathering; the second chick, still displaying its down, was hatched by the same parents about a week after the first.

The blackfooted penguin, from the west coast of South Africa, is also known as the jackass penguin, a name derived from its braying voice. Although one of the most common species of penguins exhibited in zoos and aquariums, it is not often bred in captivity.

Wildlife Imported Into the United States in 1968

The figures on wildlife imported into the United States last year are in. Entering the country in 1968 were: 140,858 mammals, including 124,440 primates; 492,280 wild birds, *not* including canaries or psittacine birds; 64,254,190 live fish; 170,621 amphibians, a considerable number of which were frogs; and 1,950,091 reptiles, varying in species from large snakes, such as boa constrictors, phythons, and cobras to small caimans and chameleons.

Ninety-two percent of the imported wildlife came by air carrier, and the main port of entry was Miami and the southeastern United States.

This report is based on information supplied in declarations for importation of wildlife, which must be filed by importers at the port of entry where customs inspection takes place. A total of 10,586 declarations were filed with U. S. Customs officers and transmitted to the Bureau of Sport Fisheries and Wildlife, Department of the Interior, which compiled the report.

Comparison with the figures for 1967 – the first year that virtually complete records were obtained at the port of entry – shows that the importations of mammals and primates, wild birds, and live fish have more or less doubled in number, with amphibians showing a small increase.

A marked jump is seen in the importation of reptiles, which has increased almost five-fold in only one year.

The increases may be attributed in part to more complete records having been obtained during 1968, but in the end the figures speak for themselves.

WILDLIFE IMPORTED
INTO THE UNITED STATES

	1967	1968
Mammals	74,304	140,858
Primates	62,526	124,440
Wild Birds	203,189	492,280
Live Fish	27,759,332	64,254,190
Amphibians	137,697	170,621
Reptiles	405,134	1,950,091

THE bookshelf

Marlin Perkins' Wild Kingdom. THE MIRACLE OF FLIGHT. *By Richard Cromer and the Staff of Don Meier Productions. With 68 illustrations by Joseph Cellini. 160 pp. Doubleday and Company, Inc., Garden City, N.Y., 1968. $4.95.*

Although the more than 8,500 species of birds living in the world today are of great interest because of their wide diversity in size and habits, the greatest and most unique feature that separates them from the larger part of the animal kingdom is their ability to fly. In *The Miracle of Flight,* a book based on material used in the television program, *Wild Kingdom,* Richard Cromer attempts to explore all of the factors involved when an eagle, or a hummingbird, spreads its wings for flight, in language and terms that a young student can understand. He does a good job and includes a great deal of general information on avian physiology. There are some statements in this line, however, that are misleading. One example is on page 121, where reference is made to the loon's (Gaviidae) ability as an underwater swimmer, leading one to believe that this bird normally remains below the water's surface for 15 minutes at a time. Research has shown that while loons can achieve this, under stress, they rarely remain submerged for longer than three minutes. An illustration on page 138, plotting the migration routes of six species of birds, shows the flight path of the common tern *(Sterna hirundo)* from western Canada to the southernmost part of South America, while the text, on page 141, refers to the same species nesting along the eastern coast of North America. Both statements are, of course, true but confusing to the reader unfamiliar with the distribution of this species.

The addition of a list of suggested supplemental reading after each chapter would have greatly increased the value of this volume. The illustrations by Joseph Cellini are excellent.

J. Bell

THE WORLD OF THE GRIZZLY BEAR. *Text and photographs by W. J. Schoonmaker. 190 pp. J. B. Lippincott Company, Philadelphia, 1968. $5.95.*

This volume in the Lippincott series is another worthwhile contribution to the natural history of North American animals. It is readable and has a store of generally sound information. However, a few minor qualifications must be made.

The author does recognize that the various brown bears of Eurasia and North America are considered conspecific. He then proceeds to refer to them all as types of grizzly bears, when surely usage would refer to them as brown bears with the grizzly bear as only one of the several forms of brown bears. Schoonmaker purports to be discussing the species as a whole when his material is almost strictly referable to the American inland form, or appropriately, the true grizzly bear. His book, therefore, should have been admittedly devoted to that form of the brown bear, the grizzly bear.

Intelligence ratings among different species of animals are for the most part meaningless and the one given in this book is even misleading. Further general speculations by the author on mammalian intelligence are not enlightening and do not belong here.

There are other possibly misleading statements or usages in the book, and most involve speculations or interpretations by the author. This book would have benefited by a closer scientific editing.

The author too often suggests that his material is based on personal observation which must limit the adequacy of his coverage. Library research should have emphasized data rather than historical anecdote.

Hugh B. House

BIRDS OF AUSTRALIA. *By Stanley Breeden and Peter Slater. 144 pp., over 200 photographs (26 in color), many drawings. Taplinger Publishing Co., Inc., New York, 1968. $10.00.*

This book is a collection of frequently superb, always interesting color and black-and-white photographs of Australian birds supplemented with a number of less successful drawings. The collection is held together with a short text which, after a brief introductory section, devotes three chapters to life-history information and six chapters to discussing the island continent's avifauna, habitat by habitat.

Appropriately, the picture captions are often long and important sources of information. The scientific names of most species are presented in an index but not in the text or caption. Apparently, the index is keyed to the captions but not to the text, which includes a number of bird names neither identified – nor indexed. And the text displays some interesting colloquialisms – "... an island three chains square ...," "... a gum-tree standing in a billabong ..." – which seem to add rather than detract.

The book and its photographs, of banded stilts and bee-eaters, of dollar-birds and bower-birds often at the nest or even at a sleeping roost, are a valuable contribution and worthwhile addition to the library of those interested in birds around the world.

W. G. Conway

THE DOLPHIN SMILE. *By Eleanore Devine and Martha Clark. xxii + 370 pp., photographs and drawings. The Macmillan Co., New York, 1967. $7.95.*

People have been writing about dolphins since Homer's time and *The Dolphin's Smile* undertakes to collect the most pungent stories, legends, treatises, and fantasies under one cover. By the evidence of the book, our thinking about dolphins has come nearly full circle in 29 centuries; the miscellany opens with a "Homeric Hymn to Dionysus" in which sailors are changed into dolphins, and ends with mention of Leo Szilard's story in which trained dolphins negotiated a disarmament pact and won world peace in 1988. In between are about a hundred short or long fables, articles, stories, and technical accounts of dolphins and their behavior under the headings of Ancient Dolphins, Modern Dolphins, and Contemporary Dolphins. You don't have to believe all you read about *Delphinus delphis, Tursiops truncatus,* and a few others, but the book is undeniably entertaining.

W. B.

IN BRIEF

OIL AND WATER: THE TORREY CANYON DISASTER. *By Edward Cowan. 240 pp. J. P. Lippincott Company, Philadelphia, 1968. $6.95.*

Mr. Cowan, who covered the *Torrey Canyon* mess for the *New York Times,* tells in reportorial fashion of the disaster off Cornwall.

THE WORLD OF THE CANADA GOOSE. *By Joe Van Wormer. 192 pp. J. B. Lippincott Company, Philadelphia, 1968. $5.95.*

This is another in the Living World series edited by John K. Terres. Mr. Van Wormer's 150 photographs are excellent and, as a whole, the book is informative and quite well-written.

E. R. R.

ABOUT THE authors

Edward Edelson's work appears often in *Animal Kingdom.* Mr. Edelson is familiar to those who watched educational television coverage of the last holiday meeting of the American Association for the Advancement of Science, at which he served as a commentator. Mr. Edelson is an old hand at science writing, having been science editor of the late *World-Journal-Tribune.* **Emmy Hass** needs no introduction to those who have read *Pride's Progress,* her book on the Bronx Zoo's family of lions. Her photographs of zoo animals have appeared in books and magazines on both sides of the Atlantic. **Alison Jolly** is a biologist and author. She has written for *Animal Kingdom* on the lemurs of Madagascar and on the biological effects of the Torrey Canyon disaster. **F. Wayne King** is curator of herpetology at the Bronx Zoo. **Gerald S. Lentz** is assistant director of the Oklahoma City Zoo. **George B. Schaller** is a research associate of the New York Zoological Society and author of several books, including *The Year of the Gorilla,* and co-author of the recently published children's book, *The Tiger: Its Life in the Wild.*

ILLUSTRATION CREDITS

Front Cover – N.Y.Z.S., George B. Schaller; pp. 2-3 – From a photograph, N.Y.Z.S., George B. Schaller; pp. 4-7 – N.Y.Z.S., George B. Schaller; p. 8 – From photographs by Allan D. Cruickshank from National Audubon Society; p. 11 – N.Y.Z.S.; pp. 13-17 – Emmy Haas; pp. 18, 20 – N.Y.Z.S.; p. 21 – Dick Lowry III (top), and N.Y.Z.S., William Meng; p. 22 – Dick Lowry III; pp. 23-24, 26-28 – N.Y.Z.S.; p. 29 – William Partington, Florida Audubon Society; p. 30 – N.Y.Z.S., U. Erich Friese; Back Cover – N.Y.Z.S., William Meng.

DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

Texas Blind Salamander

Typhlomolge rathbuni Stejneger

The Texas blind salamander is one of the rare troglodytic or true cave-dwelling salamanders in North America. It is found only in the underground streams and pools of the Purgatory Creek system in Hays County, Texas. This subterranean stream system lies in the edge of the Edwards Plateau, the high table land of central Texas. At the present time the only access to the Purgatory Stream system is through Ezell's Cave in the city of San Marcos. A number of deep wells once penetrated this stream but they have all been capped, leaving Ezell's Cave as the only entrance.

Like many true cave animals *Typhlomolge* is blind. Its vestigial eyes, small and black, are completely covered by the skin of the head. However, this salamander can detect the difference between light and darkness.

The Texas blind salamander has pink external gills throughout its life. Adults are approximately three to four inches long. The legs are spindly and the snout is so flattened that the head takes on a duck-like appearance. Due to a lack of pigment in the skin, the body has a pale white opalescence, which imparts a ghostly appearance that somehow seems appropriate for a subterranean animal. Few, if any, *Typhlomolge* are living in zoological collections.

Ezell's Cave would be unique enough if it were just the home of the Texas blind salamander. But other unique cave-dwellers live there as well. Several species of planarian worms and crustacea found there are found nowhere else. The cave once was the roost of numerous bats which supplied the energy source needed to support this assemblage of cave animals in the form of fresh guano. In recent years, however, the cave has been sealed with a metal door to keep out unauthorized visitors. Unfortunately, it eliminated the bats as easily as it did the humans, and without the bats, the guano was depleted, and the rare cave animals cut off from outside energy slowly starved. The entire ecosystem of the cave began to collapse. Today the animals are still present, but extremely rare. The Texas blind salamander is on the verge of total extinction.

Because of growing concern over the deterioration and possible extinction of the unique cave fauna, the Texas Chapter of the Nature Conservancy purchased the cave for a scientific preserve. They plan to make Southwestern Texas State Teachers College in San Marcos permanent custodian. Efforts are being made to restore the cave community to its former balance. The door has been removed and hopefully bats will be reestablished and the guano replenished. Collecting will be strictly controlled by the college, and unauthorized visits will not be permitted.

Several conservation organizations have contributed to the Nature Conservancy to help defray the cost of the purchase. Among these are the New York Zoological Society and San Diego Zoological Society.

F. WAYNE KING

THE WORLD OF DARKNESS

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animal kingdom

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ABOUT THE ISSUE

This issue of *Animal Kingdom,* designed as a special booklet, ushers you into a world that is strange and at times more than just a little mysterious to man. The issue introduces readers of *Animal Kingdom* to the Bronx Zoo's World of Darkness, a new and exciting zoo exhibits building. With the public opening — June 12, 1969 — of the World of Darkness, the techniques of presenting zoo animals in environmental and thematic exhibits reach a new level of achievement — evidence that zoos have evolved into institutions uniquely able to interpret the totality of nature for man.

The World of Darkness was made possible by the interest and generosity of The Vincent Astor Foundation through a contribution to the New York Zoological Society and by the City of New York through the Parks, Recreation and Cultural Affairs Administration. The building was constructed at a cost of approximately $660,000. Exhibit preparation, completed at a cost of more than $100,000, was executed and funded by the New York Zoological Society.

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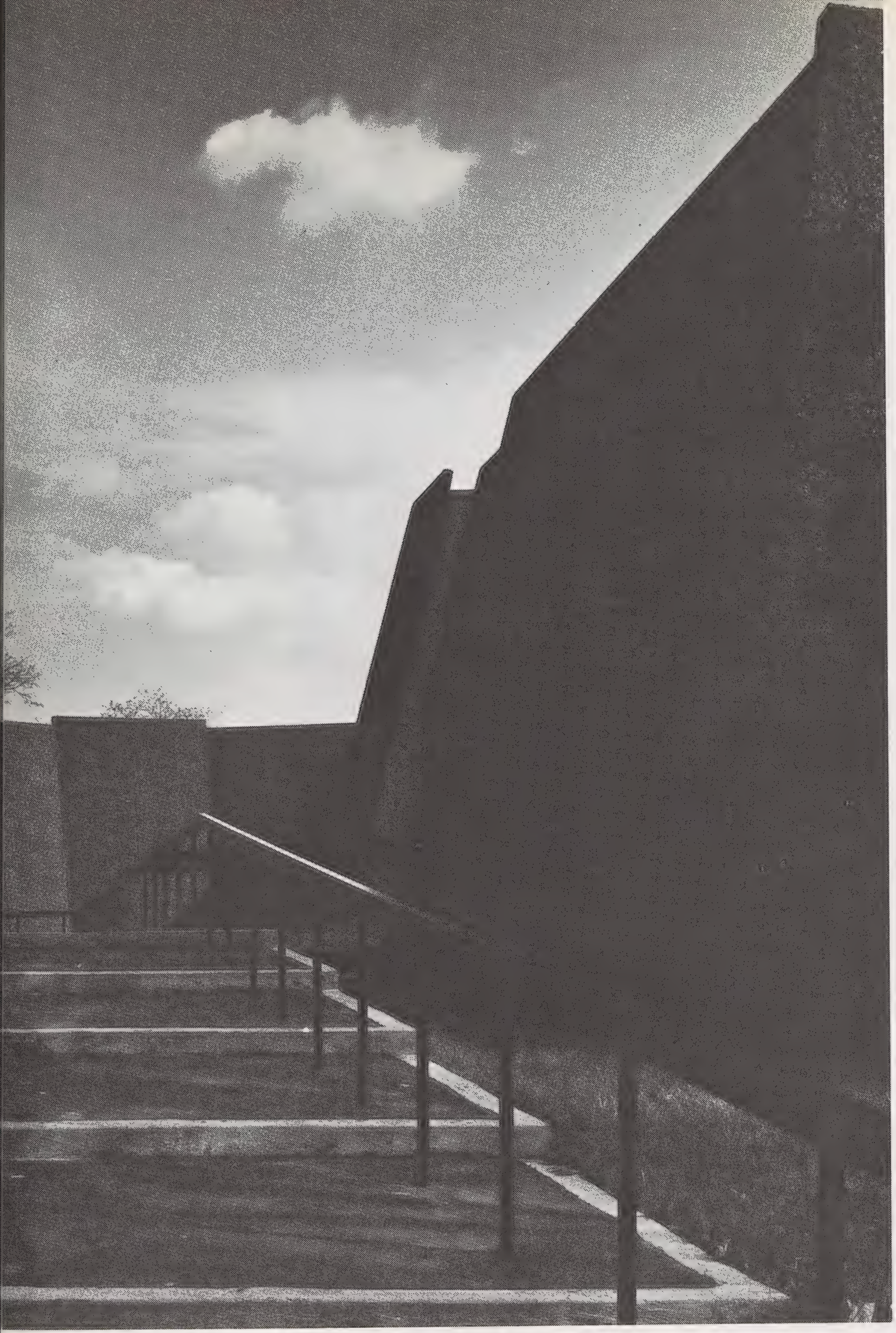
With the opening of the World of Darkness, the educational exhibition of wild animals has taken a dramatic step forward. The exhibits of night-active creatures are interpretive and environmental, and such could hardly be more timely.

There is a national – indeed a worldwide – surge of concern for the quality of our environment. People are beginning to realize that we, in ever increasing numbers, cannot go on polluting and destroying wildlife and wild lands. These renewable resources are among the building blocks of our life system and their despoliation means the progressive destruction of the quality of our own lives as well as of our natural environment.

We have come to realize that the frontiers of environmental conservation are no longer in the far-off wildernesses, but rather in the cities outside our very windows. Here is where the problems of a polluted

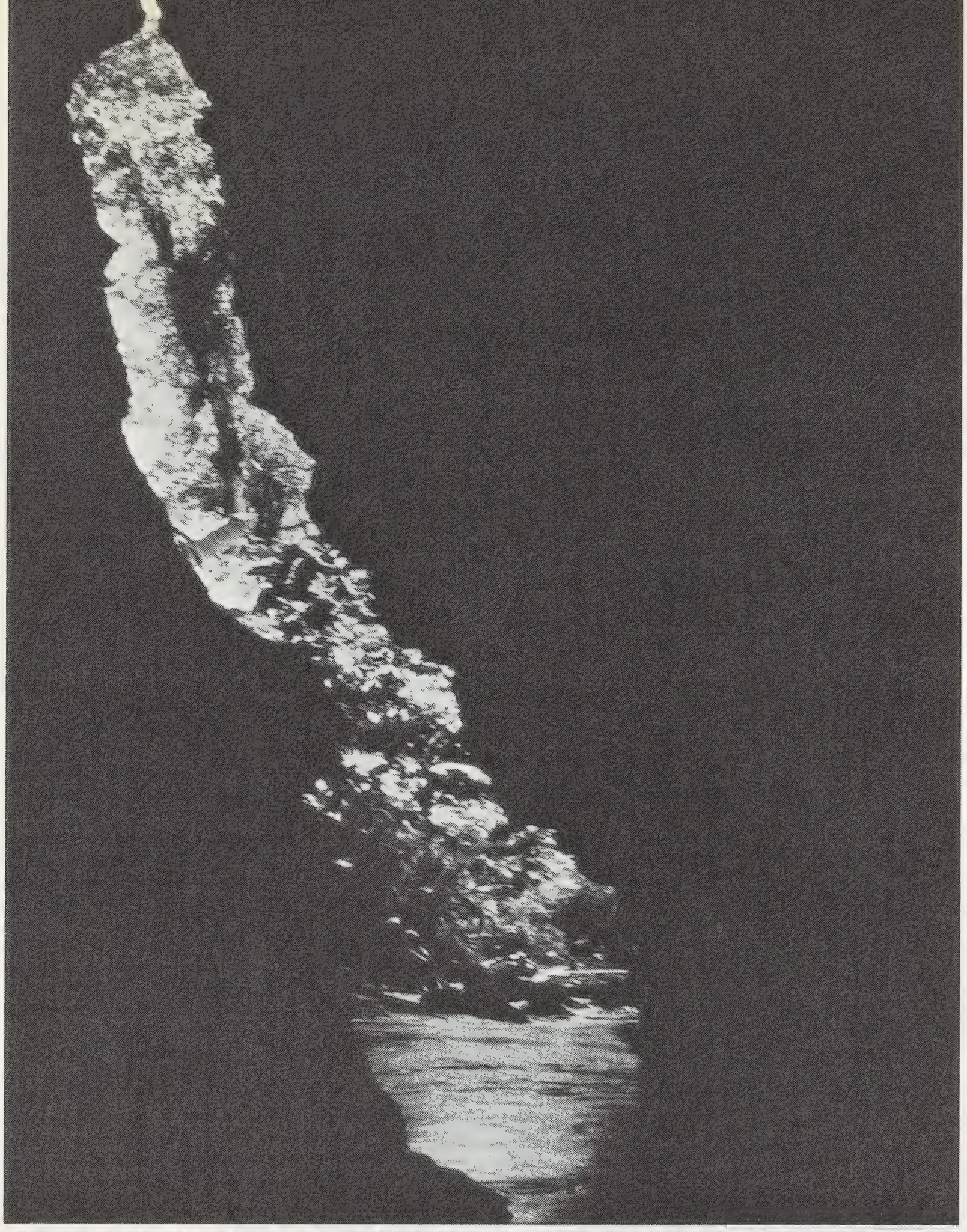


environment are the most difficult. Here is where natural recreation opportunities are scarce.

The Zoological Park stands in a unique position to make a contribution to the solution of these problems. It is a thoroughly urban institution steeped in the relationship of living things to their environment. No institution is in a better position based on actual experience to engender a feeling for the immediacy and the urgency of creating a livable environment for man and other animals. If the fascinating and esthetically commanding exhibits in the World of Darkness stimulate public concern and satisfy personal interest, they will have been successful.

Laurance S. Rockefeller

President, New York Zoological Society



A WORLD OF DARKNESS IN THE ZOO

BY WILLIAM G. CONWAY, GENERAL DIRECTOR
NEW YORK ZOOLOGICAL SOCIETY

Night after night I had tramped through the overwhelming vegetation of the tropical rainforest, seeking night birds with a flashlight. It was April, 1959, and I was at Simla, the New York Zoological Society's tropical field station in Trinidad, where *Nyctibius grandis,* a bird more commonly called the great potoo or "poor-me-one," was my special interest. Listening to the jungle at night and picking my way along the paths, wary of stepping upon a nocturnal fer-de-lance or even a scuttling red land-crab, I had followed the great bird's ineffably sorrowful notes, "poor-me-one-all-a-lone," as they descended a scale and reiterated the creature's local name. In the same way, but with better success, a thousand miles to the north, I had followed the more abrupt calls of the potoo's smaller relatives, the whip-poor-will and the chuck-will's-widow. Here, however, one brief glimpse of great orange orbs — potoo eyes reflecting my headlamp — was my only reward. A spectacled owl and a "gumby bird," the Trinidad pygmy owl, were more patient and gave me brief views before slipping silently away. Of nocturnal mammals, such as the paca or the silky-anteater, I saw nothing. Only a few frogs, calling assiduously, permitted prolonged inspection.

William Beebe waited up for me at the station and, upon my return, we sat in moonlit darkness to gaze out over the Arima Valley at the open-end of the main laboratory. As bats swooped back and forth around his old yellow rocking-chair, Will thoughtfully speculated about the nocturnal creatures in the jungle about and below us, while I involuntarily ducked each time a great *Phyllostomus* or erratic *Saccopteryx* swerved past my ear. Even as the great naturalist shook his head over the paucity of our understanding of night-active animals, he launched into a discussion of vampire bats and theorized on how many of the scores of flitting shapes before us might be

Desmodus. Long ago, in Guiana, Will had spent a night in the jungle with his foot exposed in the hope of seeing vampires stealthily settle upon it, slice an opening in the skin, and consume the blood from the wound. At the end of his story, I retired, uneasily protected by a mosquito-net in an open-windowed bedroom where I could hear the potoos calling, but also the occasional whisper of bat-wings as the little mammals made cursory flights about the bed.

At two o'clock in the morning, a pressure on my right foot gradually awakened me in the darkness, and with a frightened shout, I leaped up to confront my own vampire – and to find Will in his pajamas, equipped with a flashlight and an over-large grin, pinching my big toe. No matter how dispassionate the biologist, or how improbable the occurence, events and creatures cloaked in the mystery of darkness convey an unreasoned fear and fascination.

Myth and legend have made the world of darkness a fearful world of ghosts and vampires, werewolves and hobgoblins. The lightless parts of our planet – dark temporarily because of night or permanently because of location underground – are truly a world apart from that of day. In short, they form a unique environmental complex, fascinating to a great degree because of its mystery. This is the "World of Darkness" that is the theme of an extraordinary new exhibits building at the Bronx Zoo in New York City.

When the sun sets and night approaches, we city-dwellers continue our activities only by making our own light, and even then in only a very circumscribed way. In megalopolis, apartment denizens put their children to bed and cover their canary cages, tacitly assuming that their own artificially-prolonged activity is exceptional in an otherwise somnolent world. The country-dweller knows better. Sunset, not sunrise, is the wake-up signal for much, if not most, of the planet's life. The world of night is a rich one, and to the naturalist, the mystery and variety of animal life at night is almost as frustrating as it is astounding.

At least 60 percent of the world's land vertebrates are active by dark. Although we know *which* animals are nocturnal, very much less is known about *why*. Yet it is clear that almost all wildlife communities have strongly developed rhythms of activity. In green plants, photosynthesis can occur only during the daylight hours, and most animals also adhere to specific patterns of daily activity. The majority of reptiles are, or at least were, diurnal, while their evolutionary descendants, the mammals, are mostly night-active – in New York as well as in Trinidad. Primitive mammals may have found less competition from the ruling reptiles during darkness, and in addition, mammals, which can maintain their own body temperatures, are better adapted to the cool of the night. The fact that most mammals are color-blind is probably related to their nocturnal history, for color-perceiving cones are of little use to the retinas of eyes which must operate at low light levels. On the other hand, most amphibians, whether they be frogs calling in a Trinidad rainforest or toads trilling around a Canadian pond, are also night creatures. Perhaps this reflects the advantages of generally humid night air for creatures with moist skins which must avoid the desiccating effects of midday sun. And, it may also reflect a response to the dominance of *their* descendants, those diurnal reptiles. Fortunately for the international interest in bird-watching, not only that covered canary but the vast majority of birds are diurnal; and happily many insects and other invertebrates are nocturnal or crepuscular, that is, most active at dawn and dusk. In fact, among the insects only the bees, wasps, and butterflies are usually fully active by day. All this indicates that zoos must have always shown by day many animals which are normally active at night.

The alternation of day and night activity in animal communities offers at least as many advantages as day and night shifts do for manufacturing plants. It means that many more animals may dwell in the same area without direct confrontation and competition, but it implies that even the barest comprehension of animal interrelationships requires a recognition of important activity patterns – and especially those of animals active by dark. But most of this darkened world has remained hidden to people interested in animals, even at the zoo.

Although zoos have long contained night animals – bushbabies and owl monkeys, pottos and geckos, lorises and frogmouths, and even an occasional bat – they have been unable to actually *exhibit* them. The zoo-goer, peering into a darkened cage, was lucky to view an undifferentiated lump of fur which, according to its label, was really very strange and curious looking. Yet zoo experiments intended to reveal the strange appearance and curious habits of night beasts have been underway for a long time.

At first, zoos simply attempted to cater to their charge's aversion to light by keeping displays dimly lit. Even under these conditions, however, the animals slept all day and their bizarre faces were known only to their keepers and curators. In a few zoos, curators attempted to create a moonlight atmosphere in enclosures for night animals through the use of bluish lightbulbs. But the cyclic nature of the animal's activity, the differentiation of light and dark, was overlooked.

Then, perhaps realizing that nocturnal animals *did* completely reverse their activity schedules when transported halfway around the world and readily adapted to sleep and active patterns different by 12 hours from those of their homeland, Ernest P. Walker of the National Zoological Park initiated some promising experiments. In the 1940's Walker not only darkened his nocturnal exhibits by day but, just as importantly, lighted them brightly at night, thus completely reversing the animal's cues to sleep and "work." For light, during the visitor's day, Walker employed daylight filtered through blue or blue-black cellophane, and the experiment was successful in principle, for the several animals so treated became more active during zoo-visiting hours and slept during the artifically-lighted night. However, the exhibits appeared to be too dim for good viewing in relation to the public space and, perhaps, too bright to permit full activity for the animals. Exhibits, similar in principle, were developed further at the Chicago Brookfield Zoo by Robert M. Snedigar and, later, in Great Britain. There, Director G. S. Mottershead of the Chester Zoo and Director R. E. Greed of the Bristol Zoo experienced considerable success with a reversal scheme using blue fluorescent lights on kinkajous, armadillos, genets, palm civets, jerboas, and even owl monkeys. Nevertheless, visibility and animal activity were apparently insufficient, for few zoos were encouraged enough to follow suit.

Active exhibits of nocturnal animals remained a challenge but, at the same time, another system was developed at the Arizona-Sonora Desert Museum in Tucson. There, burrowing, cave, and crevice-inhabiting species of mammals and reptiles are maintained in simulated-habitat exhibits along a darkened underground passageway. In order to see the animals, the visitor depresses a section of the public railing which activates normal white lights within the display. Surprisingly, the animals seem to adapt to these alternating flashes of white illumination, and the visitor may often see them alert and active, although their activity cycles are not reversed. The system has been adopted, with modifications, at several collections including the Pittsburgh Underground Zoo and the small mammal house at the Philadelphia Zoo. Nevertheless, the flashing is annoying to some zoo-goers if not to the animals, and the view of the animal's activity and behavior is a restricted, fragmentary one. Essentially, this system lacks the opportunity for continuous observation of undisturbed animals employing their specialized senses in the dark, and so it seems unsatisfactory for exhibition or research.

Still other systems for seeing animals in the dark remained to be tried. Infrared "snooperscopes" or "sniperscopes" had been developed during World War II and infrared photography was also well advanced. But the "sniperscope" did not seem to be the answer for the zoo, as infrared radiation is invisible to the human eye; in a sniperscope device an image is cast on a small screen by means of electronics, which in the case of zoo animals is a poor substitute for direct observation.

Observations by many biologists had shown that the eyes of nocturnal animals are usually insensitive to red. Their retinas are poorly supplied with color-perceiving cones, which require high light levels, and richly supplied with rods, which are effective at very low light levels but see the world in shades of gray. Thus, in 1960, Joseph A. Davis, Jr., of the New York Zoological Society, rejected the blue-light approach to exhibiting nocturnal animals and, in response to the perceptual limitations of the eyes of many night animals, began experiments with simple, visible red light — not infrared.

Mr. Davis knew that Professor Lee R. Dice had concluded that an owl could see a white mouse on

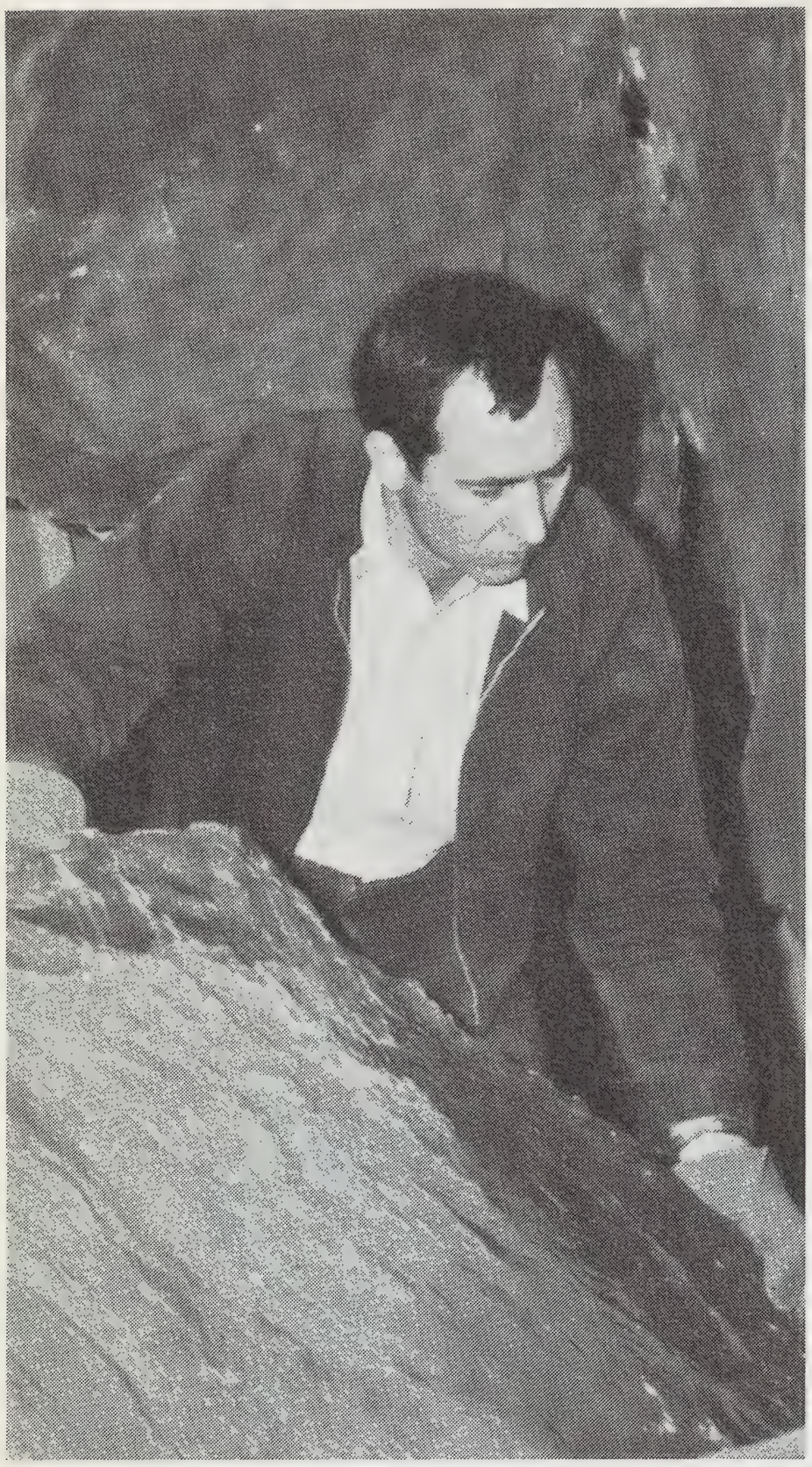
dark soil in less than one-millionth of a foot-candle of light and see in light between one-tenth and one-hundreth the minimum intensity necessary for man. Therefore, he reasoned, exhibits employing colors of light visible to both zoo-goer and nocturnal animal would usually be too dark for the zoo visitor. Mr. Davis concluded: why not forget the dim, simulated moonlight and try bright red light?

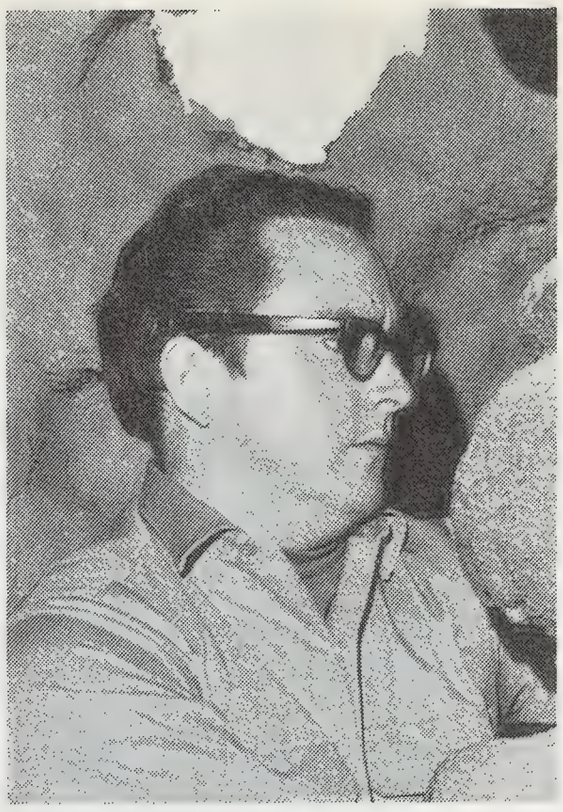
Mr. Davis' red light experiments at the Bronx Zoo proved successful and formed the basis for the development of the World of Darkness. The reason for using red light, he noted, lies in the peculiar spectral sensitivity of visual purple, rhodopsin – the light sensitive pigment in the retina of the eye which builds up within the rods during darkness. Deep red in color, visual "purple" absorbs all visible light but red, which it reflects. It converts the energy of the wavelengths, or colors, it absorbs into the sensation of light. In short, red is practically invisible to nocturnal animals whose retinas are composed largely of rods. Using bright white light at night and bright red light during the day, an experimental section of the Bronx Zoo's

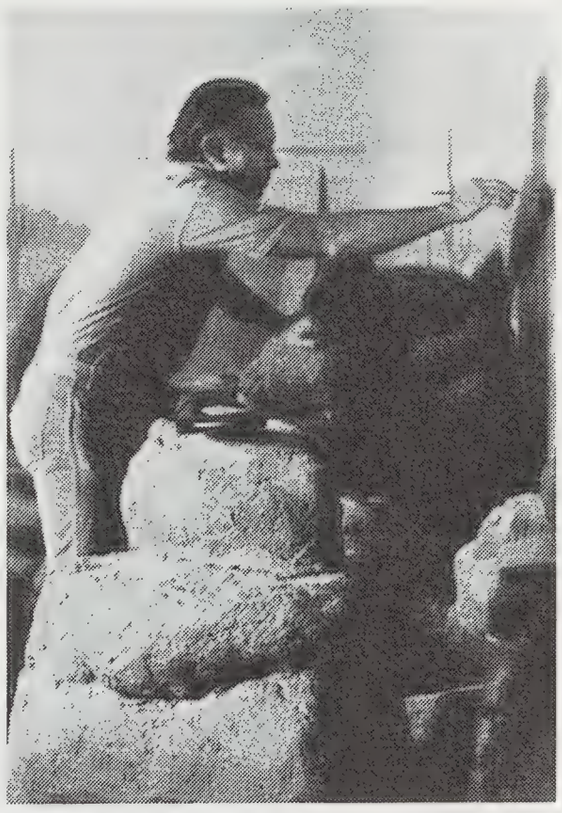
As darkness descends, much of the animal world awakes. The tawny frogmouth (opposite, upper left), a forest bird of Australia, feeds at night, mostly on the ground or on the branches of trees, which it so much resembles in coloration. The leopard cat (above), in size hardly larger than a house cat, roams its native haunts throughout most of Asia and south through the islands to the Philippines. And the galago (at left), found over most of Africa south of the Sahara, leaps through the trees in its nighttime search for food.

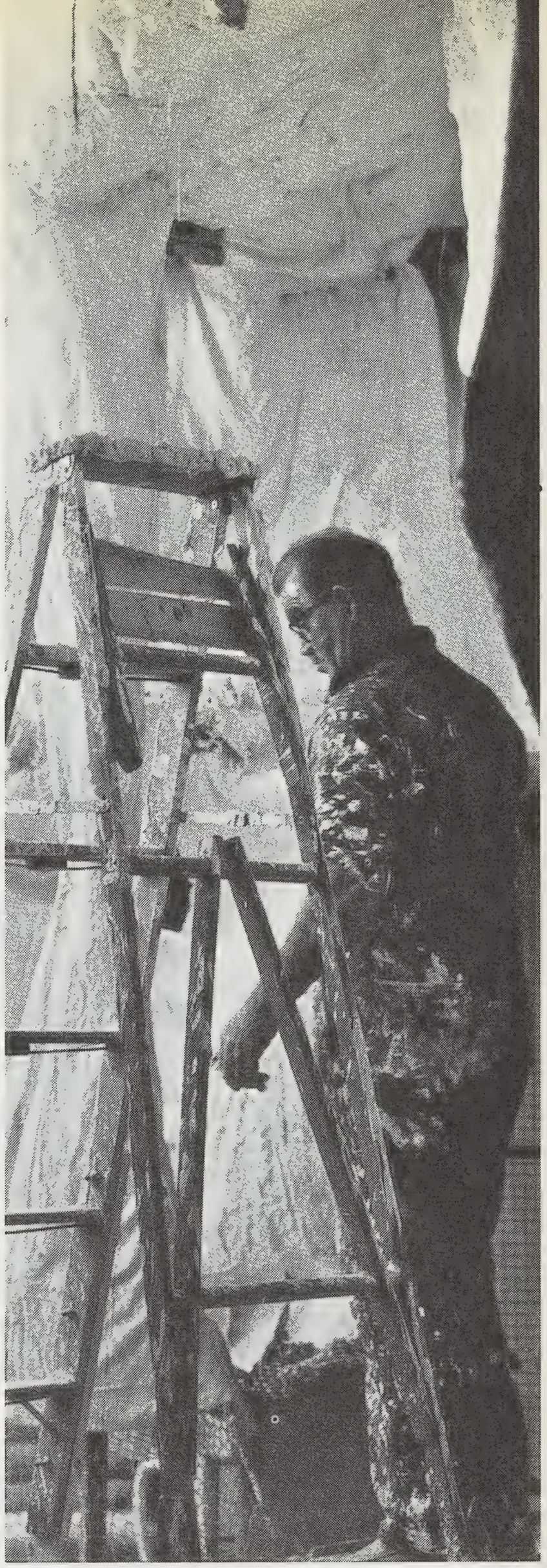
small mammal house was so successful that, unlike earlier blue light efforts, it was soon widely emulated. Active night animals may now be viewed in "red light" rooms and buildings in zoos in Milwaukee, Cincinnati, Houston, Chicago, Washington, and elsewhere. However, no vertebrate is continuously active, and nocturnal animals rest at night just as diurnal animals rest during the day. And of course there remains room for further improvements on the system.

Unfortunately, some zoo visitors complain that red light bothers their eyes and there is no doubt that it limits the perception of the animal's color and that of its surroundings. Further experiments

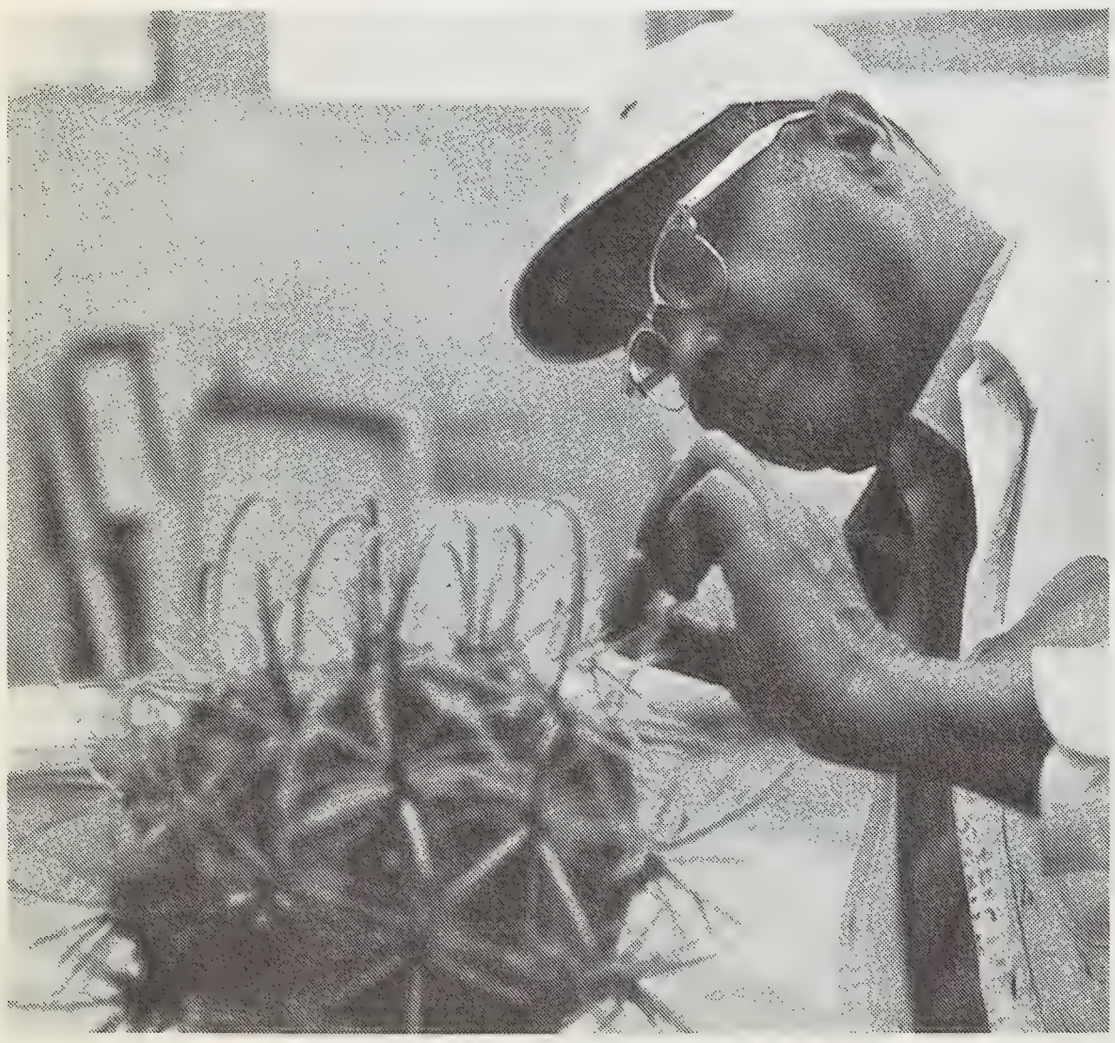








To the Department of Exhibition and Graphic Arts went the task of building the habitat exhibits for the World of Darkness. Jerry M. Johnson, the department's curator (above, at left), designed and executed the exhibits with the expert assistance of the people in his department, among them: James Oslund, exhibits artist and sculptor (center, at top); Sheridan Oman, who came from the Arizona-Sonora Desert Museum to paint the backgrounds for several exhibits (center, at bottom); artist and designer John Sutton (at right): Albert Russell, who made some of the largest casts of natural objects ever attempted in plastic (below, at left); and graphic designers Eideen Molloy and Barbara Lee Syvertson (below, at right), shown in their studio surrounded by sketches for the building's graphics.



have been carried on at several zoos which ignore rhodopsin and depend simply upon varying the intensity of white light. At Amsterdam's "Wereld der Duisternis," a name borrowed by Dr. E. F. Jacobi from the Bronx Zoo with our permission, daylight-type fluorescent light is kept dimmed during visiting hours to approximately 0.5 foot-candles and raised at night to about 10 foot-candles. When I visited this exhibit in 1963, I found most of the collection active, including slender lorises, slow lorises, galagos, and cuscus. However, the light was so low that visibility was poorer than under the red light scheme. A similar exhibit developed later at London was also reasonably successful, at least with some species. At both collections, it seemed to me that a greater difference in light intensity between the "day" and "night" cycles might have permitted a higher light level during visiting hours. However, the limits of white light intensity that various nocturnal species will tolerate and still remain active have not been determined. It is clear that as time goes on, minor, perhaps species-specific, improvements will be made in lighting systems and, for this reason, the lighting of the World of Darkness has been designed with great flexibility.

As the concept of the building developed, it became clear that the introduction of nocturnal animals would require a most unusual design. A structure exhibiting bats, pottos, alligators, and owls is not likely to be conventional. Not only special animal-care and exhibition techniques were needed, but also carefully thought-out methods of exhibition presentation, servicing, and public circulation. The design program for such an exhibit cannot be set forth in a brief description of cubicles like an office building; it must evolve in the course of countless meetings between zoo-men and architects, in this case the firm of Morris Ketchum, Jr., and Associates.

Mr. Ketchum surveyed the zoo for possible sites, then chose a spectacular rock outcrop in a decentralized position, to better aid the zoo in dispersing its burgeoning crowds. One-way circulation through the building was an essential, and his design response was a horseshoe-shaped structure in which the exit is concealed from the visitor, although it is actually adjacent to the entrance. The nature of the exhibit begged for special character and the accompanying pictures speak best for the success of the design. Speaking of the World of Darkness, Mr. Ketchum said: "Here was a unique opportunity to create the first building of its kind – a challenge no architect could resist .... Psychological considerations governed our choice of black for the exterior. Black offers a feeling of mystery, suggests nighttime, and subdues the apparent size of this large building .... New York soot will add, not detract, from this black foolproof surface."

Of course the interior offered the greatest design problems, for the exhibit was to be a carefully structured esthetic and educational presentation in which each display was planned not only to meet the needs of its inhabitants but also to expand the visitor's interest and knowledge.

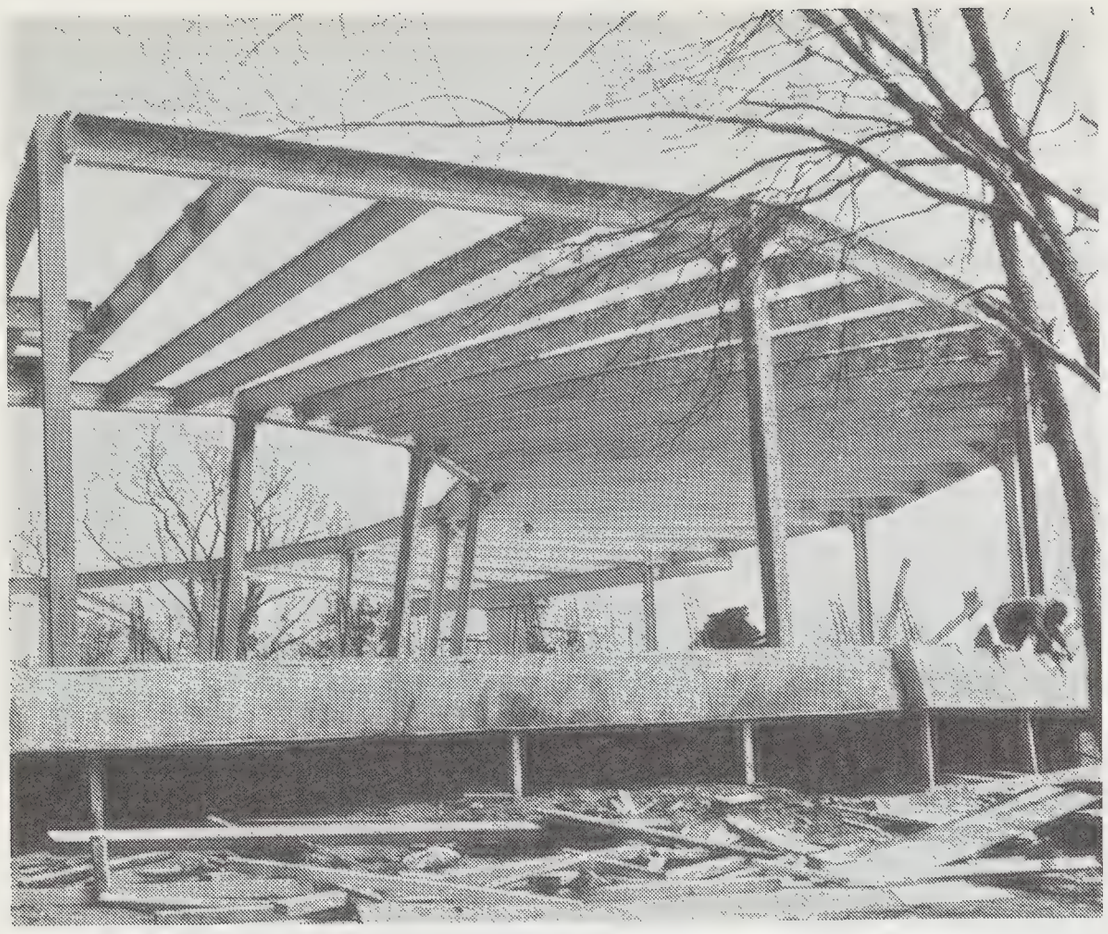
The exhibits are divided into three halls entitled, "The Forest After Dark," "Wings in the Night," and "Refuge Underground," and each of the 30 major displays attempts to convey some new aspect of the animal world at night and its relation to man. The building is primarily a teaching instrument, not a wild animal breeding facility, and although breeding will be encouraged, endangered animals will not normally be shown; yet conservation is one of the structure's major objectives.

Conservation in urbanized countries like the United States is no longer only dependent upon those who live in wild areas. More than 70 percent of our population now dwells in cities and it is here that attitudes, and their resultant votes, will determine the future of wildlife and wild lands. Ironically, the decisions will be made by people almost totally unfamiliar with living wild creatures, except those animals seen at the zoo. To gain the interest – the attention – of this great majority of inexperienced city-dwellers has become a basic responsibility of modern zoo displays. If the new exhibit aids in this effort, it will have been successful, and the World of Darkness has employed a great variety of ingenious devices to accomplish this end.

The zoo-goer enters the exhibit through a light baffle, a gradual introduction to the darkened public space. The first sign he sees reads simply, "Day and Night" and under it are two identical forest displays. In all ways but one the displays are artfully identical – right down to every rugosity of tree bark, each fallen leaf, acorn, branch, and twig. The difference is that the first display portrays night and the other day. Each is inhabited by a chipmunk and a flying squirrel, the first diurnal and active in the day exhibit, and the second nocturnal and active in the night display. Thus the building and its theme are introduced.

Artful is hardly a sufficient word to describe the complete duplication of two simulated habitats side by side. Of course, there is only one way of really doing such a thing: cast them from the same mold. And this is exactly what was done, in fiber glass by the zoo's department of exhibition and graphic arts.

The New York Zoological Society's curator of exhibition and graphic arts, Jerry M. Johnson, has assembled an extraordinary group of artists work-



ing in the most modern of materials to produce permanent zoo habitat settings. Plastics and even gunite are combined to present animals in backgrounds comparable to those in natural history museums, but in ways which allow for cleaning and care and which provide opportunities for the animal to employ and to exhibit more of its specialized behavior in a setting meaningful to the zoo visitor. A rejection of the tile bathroom-like treatment of some zoo exhibits, which always seem to me to make the animal an out-of-place caricature of itself, this form of exhibit technique places the wild creature in a background suggesting a part of its wild home and provides, instead of the usual square flat-floored cage, a three-dimensional enclosure with places for the animal to climb, if that is its nature, or to hide or to swim or to fly. Activity is not dependent upon lighting alone; many animals must have variety and dimension if they are to actively adventure in their homes.

After the "Day and Night" displays, several exhibits face the viewer. An owl display, entitled "Color at Night," is an example of another approach. Fronted by three glass-panes which are, respectively, red, clear, and blue-green, the display teaches the zoo-going child that he is practically invisible to the owls when he stands behind the red pane, for this, of course, is that part of the spectrum which nocturnal animals see poorly. In contrast, when standing behind the blue-green pane, he perceives that part of the spectrum nocturnal animals with their rod-rich retinas see well.

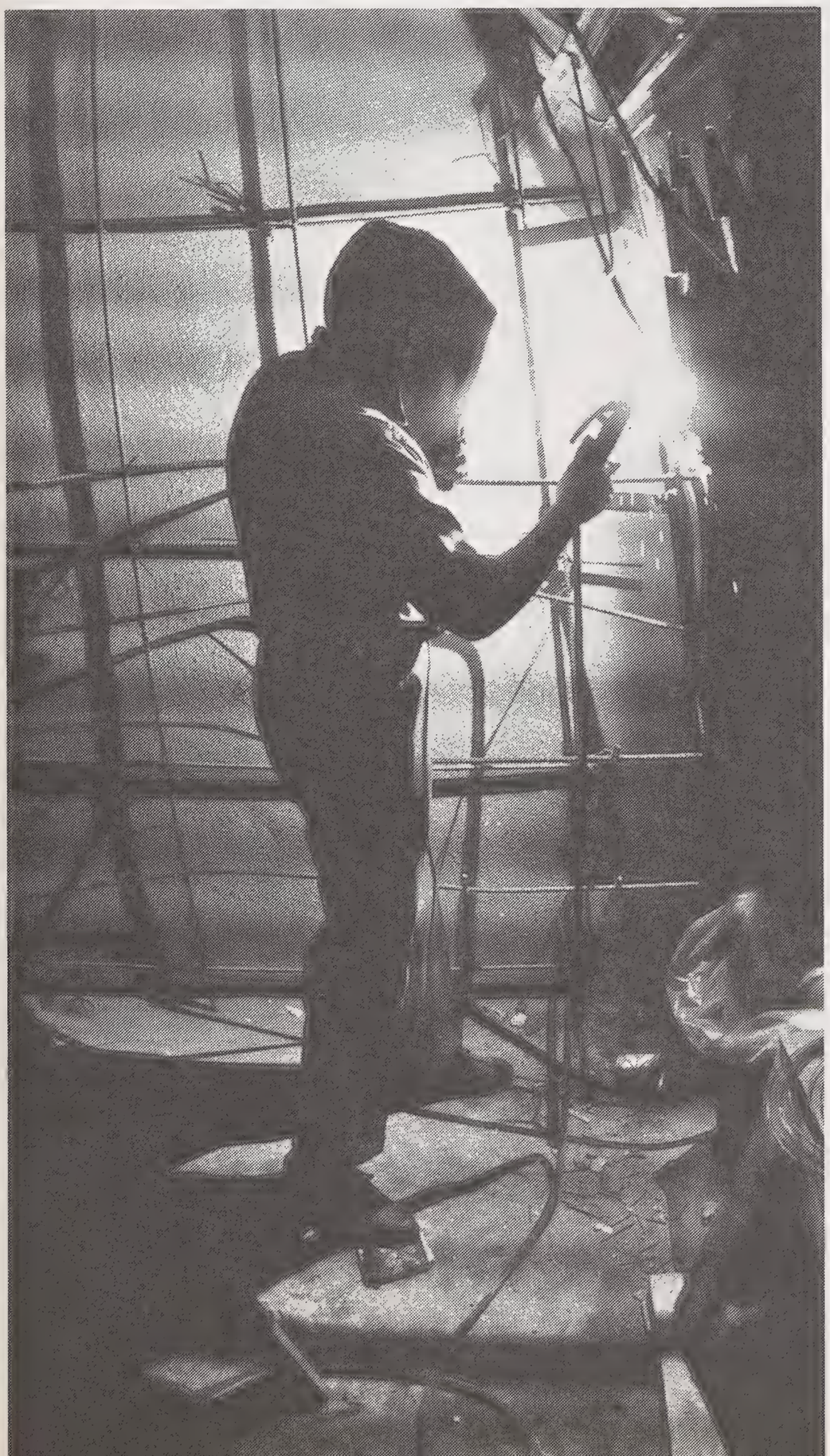
Contrast, in fact, is a major device in the building. While still in the "Forest" hall, the visitor observes a forest floor, its denizens slipping past great stumps and trees. Then, rounding a corner, he is confronted with a series of tree-top vignettes of arboreal mammals, birds, and reptiles. Tree snakes, owl monkeys, slow lorises, pottos, and their fellows are seen, while their specializations are interpreted in a colorful graphic sign entitled, "Life in the Tree-tops, Another Dimension in Living." At strategic points, further along in the building, are other interpretive displays on the senses of nocturnal animals, on animals which dwell underground, and on the conservation of vanishing nocturnal species.

Next, the visitor finds himself attracted to a nearby swamp by a swelling frog chorus, or by the roar of a bull alligator. Although these sounds are taped and the tall cypresses which extend up out of sight are fiber glass, the alligators which float quietly at their feet are real, and so are the skunks and raccoons which occupy the shore behind them (where a glass separator rules out inadvisable fraternization). Other displays in the "Forest After Dark" exhibit such nocturnal predators as snakes

and frogs and even leopard cats.

The second hall, "Wings in the Night," presents owls and goatsuckers – perhaps some day a poor-me-one – where they vie for attention with flying squirrels and bats. Again, contrasts are accented in side by side bird exhibits, one a snow scene, the other a jungle. The dominant display is a demonstration enclosure some 30 feet long where bats may swoop back and forth over a long shallow pond to scoop fish from the water in front of the viewer's eyes. At the same time, electronic equipment brings their ultra-high frequency calls within man's limited hearing range as the bats attempt to echolocate their prey in daily demonstrations. Movies and slides projected on four screens on the exhibit's back wall add a further educational dimension and bring close-up what the eye is too slow to see. Comparatively large false-vampire bats will be trained to fly to their keeper's hand for food, and eventually owls may be trained to use the flight-area at stated times. So many of the opportunities presented by the World of Darkness are new that additional demonstrations and exhibits and new opportunities for research will continue to evolve, making the display more and more exciting as time goes on.

As shown on the opposite page, the building takes shape from the architects' plans. Below, the steel armature is welded together to form the base of one of the large exhibits.

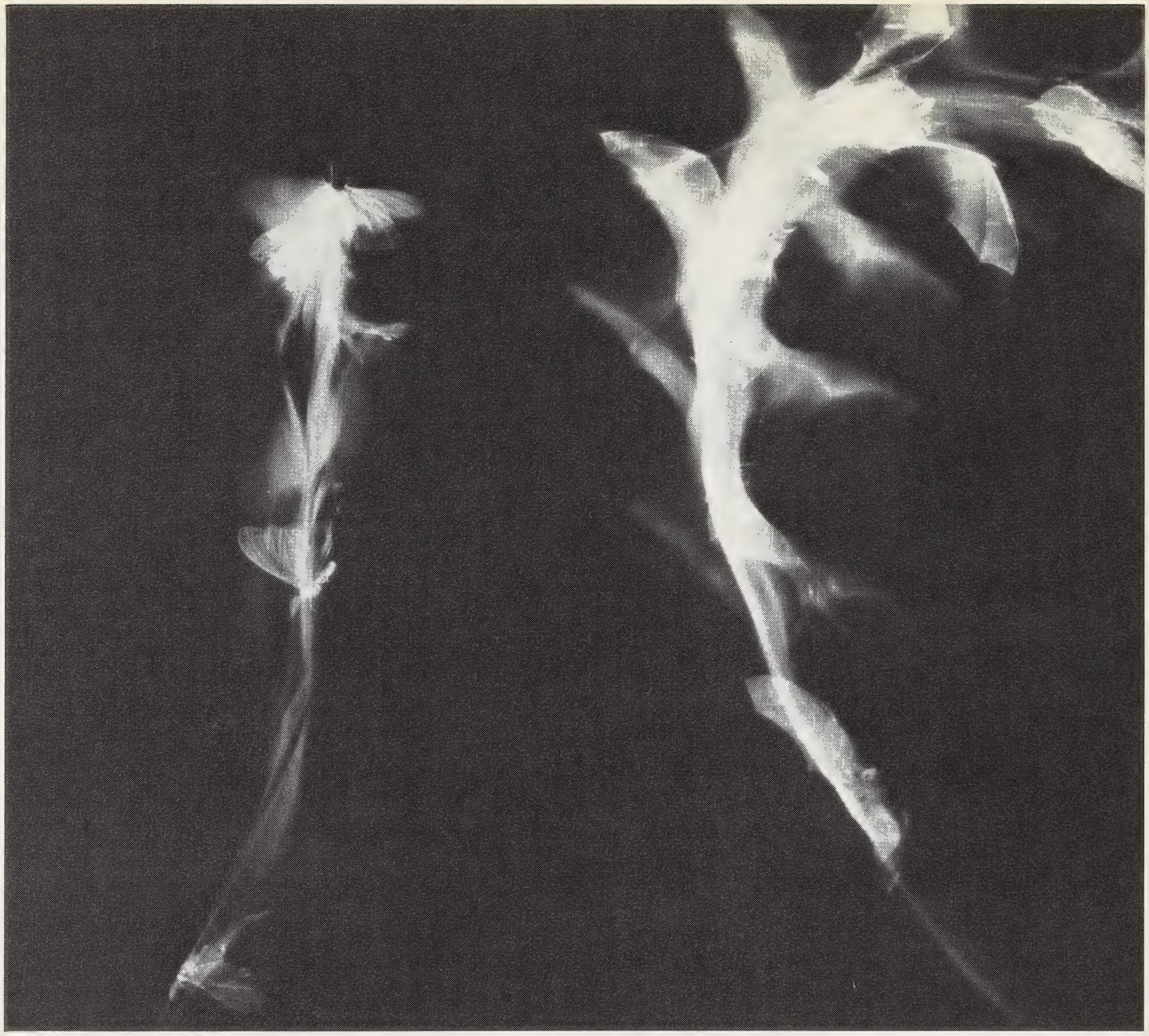


As the visitor goes on, he eventually arrives in the building's final hall, "Refuge Underground." Here not only nocturnal and crepuscular animals themselves are revealed, but also their hideaway homes in burrows, crevices, and caves. Badgers may dive into their burrow under an old stump – to stand revealed in a cut-away section of their subterranean tunnel. An aardvark lumbers back and forth in the African night from its giant-sized burrow, but a glassed cut-away section enables us to see it even when it is at home. Regardless of how the other exhibits are lighted, burrows and caves are illuminated with red light so that they offer apparent darkness and security to their owners at all times, as they would in nature.

A little further, we come upon the mysterious but unrevealing entrance to a small North American cave; we round a corner and find the cave open, in cross section, to our eyes. Bats are clustered on its roof, while blind cave fish swim carefully in the pool below them, and, nearby, blind cave salamanders undulate through their part of the cool waters as cave crickets employ their enormously elongated antennae in yet another part of the underground habitat. A further cut-away display sections a small arroyo in the desert where foxes trot and armadillos waddle between saguaro cacti while lizards, packrats, and snakes prepare to leave their sun shelters and burrows for the evening's hunting.

The last and most spectacular of the building's exhibits is a highly experimental tropical cave and associated forest. In the cave, copied largely from settings in Trinidad, bats cluster among stalactites and toads squat between stalagmites. Eventually perhaps oilbirds, those strange palm-fruit-eating relatives of the goatsuckers, will be shown here (although experiments in their maintenance have thus far proven unsuccessful). A stream runs through the cave and continues outside, where the bats swoop and chitter, and sloths slowly wend their way through forest branches, while pacas, agoutis, and tinamous pick their way along the forest floor. Will Beebe would have felt at home.

The variety and activity, strange adaptations, and remarkable beauty of night creatures will convey their own messages, but a final graphic reinforces them. It says: "In this building you have been introduced to the world of darkness; a world that represents only one part of the totality that is nature. The continuing increase in human populations combined with environmental destruction is rapidly suffocating the world of nature. Therefore, the future of all wildland and wildlife depends upon educated human protection and interest – and ultimately upon you."



BATS— ANIMAL SONAR EXPERTS

BY DONALD R. GRIFFIN
DIRECTOR, INSTITUTE FOR RESEARCH IN ANIMAL BEHAVIOR
NEW YORK ZOOLOGICAL SOCIETY—THE ROCKEFELLER UNIVERSITY

The new World of Darkness is dedicated to the majority of animal life that takes place when the sun is on the other side of our planet. Most of our fellow mammals are more active at night than by day, but bats are the most thoroughly adapted of all nocturnal mammals. For example, they fly with agile precision through the total darkness of deep caves. This is a very different matter from merely being active at night, since even on the darkest cloudy nights there is enough light out-of-doors for the dark-adapted eyes of animals and men to see dimly.

Most people are far from enthusiastic about bats. Perhaps because human vision is so highly perfected, we tend to find darkness strange and disturbing. One contributing factor in humanity's lack of fervor for bats is presumably the very unfamiliarity of an aerial way of life that calls for dexterous flight in total darkness. Yet this widespread aversion to bats stems largely from our cultural history, not from any fundamental attribute of the bats themselves. In the civilization of China, bats play a wholly different role, as symbols of happiness, good fortune, and longevity. Bats in stylized form or motifs based upon bats are prominent in Chinese art. To quote Glover Allen (*Bats*, Harvard University Press, 1939, reprinted 1962 by Dover Publications, Inc.):

"Among the Chinese, who so often see the other side of the shield, bats are held in high regard and by the Buddhists are sometimes considered sacred. In the Chinese language the word

for bat is *fu*, which also is the name of the character meaning 'happiness,' just as with us the word bee has the same sound as the second letter of the alphabet. By substitution, the figure of a bat thus comes to stand for happiness or good luck and is frequently seen worked into designs in Chinese handicraft. But again contrary to our usage, it is always represented with head pointing in and from above instead of head up and from below, spread-eagle or 'spread-bat' style. Two bats written upon a gift signify good wishes from the donor, and a talisman widely used in China consists of a disk about the size of a dollar, enclosing the symbol of life (a tree with roots and branches), and surrounded by five bats with spread wings, facing in. This talisman of the five bats—or *wu-fu*—is worn for the five great happinesses sought by all men, namely, health, wealth, long life, good luck, and a desire for virtue or, as sometimes put, tranquility."*

The bats of the Far East are basically similar to those of other continents, and hence this basic difference in their mythological reputation must have its orientation in human beliefs rather than in zoological fact. Let us keep in mind the Chinese attitude towards these marvelous animals as an antidote to the superstitions that permeate our own cultural heritage. Despite their long history of neglect and contemptuous treatment, bats have told us much of scientific significance about the relationship between zoology and technology. The natural history of bats also holds a message about alleviating the handicap of human blindness. To understand this message, we must build some bridges between the conventionally separate sciences of zoology, sensory physiology, and human psychology.

Bats fly farther than we ordinarily realize. They are less proficient fliers than birds because their wing surfaces are formed by stretching skin between slender finger bones rather than by shaping feathers into an efficiently contoured airfoil. Yet recoveries of banded bats have demonstrated seasonal migrations of 800 miles or more. Some species such as the little brown bat *(Myotis lucifugus),* whose range covers most of the continental United States and Canada, pass the winter in hibernation deep inside caves, mine tunnels, or similar retreats. Many populations of bats migrate for distances up to 300 miles, at least, to reach suitable places for hibernation. Other species migrate north and south to take advantage of shifting food supplies. For example, the Mexican free-tailed bats *(Tadarida brasiliensis),* which are astronomically numerous from Oklahoma to Arizona, migrate for the winter as far south as central Mexico.

Although we can see bats easily only when they are flying near the ground, radar observations by Timothy Williams (a former graduate student who worked with the author at the William Beebe Tropical Research Station in Trinidad) and his wife, Janet, have shown that the free-tailed bats often climb to 8,000-10,000 feet during their nightly sorties from Texas caves in search of insect food. The long distance migrations of bats, and presumably their flights to high altitudes, seem to be guided by vision. All bats have functional eyes, although these are small and nearly hidden in the fur. Hearing predominates over vision as the major "sensory window" through which most bats keep in touch with their surroundings.

Bats have been specialized and successful mammals for at least 50 million years. Extraordinarily well preserved fossil bats have occasionally been found from Eocene deposits, and surprisingly enough their anatomy differs only in minor respects from modern bats. Intermediate missing links between fully evolved bats and non-flying mammals have yet to be discovered. One major group of bats, the suborder Megachiroptera, including the flying foxes of tropical Africa, Asia, and Australia, have relatively large eyes and faces that do not differ in any marked way from those of other mammals. The remaining bats, the suborder Microchiroptera, all have external ears of considerable size and have eyes that are smaller even than those of small nocturnal mammals such as mice. Brain structure varies along with the prominence of eyes and external ears. In the Megachiroptera those parts of the brain devoted to vision are at least as large as the auditory areas. But in the brains of the Microchiroptera the situation differs, and in the basic portions of the brain, auditory areas are enormously large relative to those regions devoted to vision.

The predominant importance of hearing in the lives of insectivorous bats of the suborder Microchiroptera was discovered in 1793 by the brilliant Italian scientist Lazaro Spallanzani. During the last decade of his life, while marveling at how a variety of nocturnal animals could live without benefit of sunshine, Spallanzani was impressed by the difference between bats and owls when both were obliged to fly in total darkness. Despite their obvious adaptations for nocturnal life, owls became completely helpless in full darkness and collided with all obstacles they encountered. Bats, on the other hand, flew with completely normal agility. Because he wondered whether there might be a residual level of light by which bats could see their way even though owls could not, Spallanzani turned to direct experiments. He blinded bats and

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demonstrated beyond doubt that vision is not necessary for their agile and well-oriented flights. The same point can be established in equally convincing fashion by measurements that show the complete absence of light in deep caves where many species of Microchiroptera fly freely, with unimpaired agility and perfect orientation.

Spallanzani pursued his studies of the orientation behavior of bats much farther than his contemporaries or immediate successors bothered to recognize. Enormously intrigued by the mysterious ability of bats to fly without any assistance from their sense of sight, he and Swiss zoologist Charles Jurine experimented in a wide variety of ways with the sensory basis of obstacle detection by flying bats. They found that tightly stopping the ear canals did produce disorientation. Concerned that this might be due to irritation caused by the plugs, Spallanzani inserted minute tubes into the ears of bats and found that flight was reasonably normal so long as the tubes were open. But the bat lost its ability to avoid obstacles when the tubes were tightly closed, even though an injury or irritation by the tubes remained the same. It took biologists almost 150 years to recognize the true meaning of Spallanzani's and Jurine's experiments.

In 1938 I was an undergraduate student enthusiastically engaged in banding bats to learn whether or not they migrated. Friends urged me to visit G. W. Pierce, a physics professor at Harvard whose laboratory bristled with impressive apparatus, including what were at that time almost the only instruments in the world capable of detecting sounds above the frequency range of human hearing. When I worked up my courage to visit Professor Pierce, with a cage full of little brown bats in hand, it must have been difficult to decide who was more awed and frightened, the bats or I. Pierce was combining his lifelong interest in physics with an enthusiasm for the songs and behavior of insects, and he was as keenly interested as I in the continuous series of ultrasonic sounds which his apparatus revealed when my cage of bats was brought near it. During the next few years Robert Galambos, a fellow Harvard student, and I studied the role of these high frequency sounds in the orientation of local insectivorous bats. We found the sounds Pierce's apparatus had first detected were sonar signals, or orientation sounds, and that the orientation of bats in darkness was entirely dependent on the emission of these orientation sounds and the hearing of echoes from obstacles.

I have come to use the word *echolocation* for this natural way of orienting oneself by means of sound. Of course echolocation is analogous to radar and sonar. But the echolocation of bats is not a specialized technique, it is their way of life. The orientation sounds of bats have faint audible components which a very careful human listener can hear in quiet surroundings. The great bulk of the acoustic energy emitted by almost all those bats that have been studied lies above 10,000 cycles per second (or 10 kiloHertz, conveniently abbreviated as 10 kHz). Thus we can appreciate the acoustic world of bats only with suitable instruments to translate their orientation sound into our range of hearing. Such devices are often called "bat detectors," because under conditions of total darkness one can often discover actively flying bats that are quite invisible. A bat detector consists of a microphone sensitive to frequencies from about 10 to 100 kHz, amplifiers to increase the electrical signal from the microphone, and a circuit that converts energy from this ultrasonic frequency range into audio frequencies that in turn are broadcast from a small loudspeaker. These sounds are all of short duration, lasting only 1/1000 to 1/100 second. When captive bats are obliged to dodge wires or other small obstacles arrayed in a laboratory room, they increase the number of individual high frequency orientation sounds emitted each second. A bat cruising through unencumbered space emits only 5 to 20 orientation sounds per second, depending upon species and other conditions. But when difficult orientation problems are faced, such as a row of fine wires to be dodged, the repetition rate increases sharply to brief bursts at 100 to 200 per second. Preparing to land or to drink by skimming the surface of a pond also involves high repetition rates.

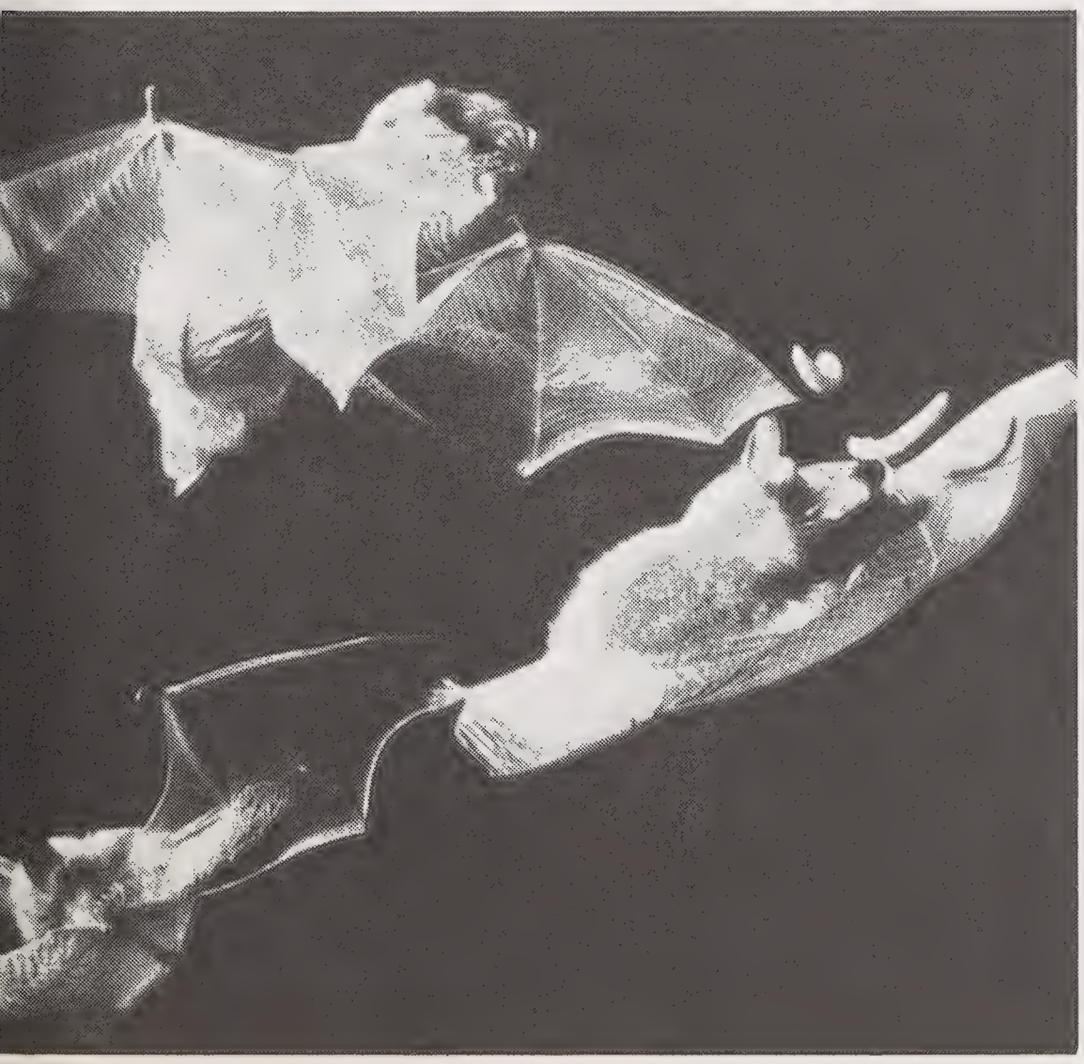
Our thinking about science tends to be constrained into conventional pigeonholes. Zoologists

On page 12 is a high speed photograph of *Myotis lucifugus,* a little brown bat, turning away from a lunar moth, apparently too large a target. The same bat is shown below.

seldom have much interest in bat sonar, because it requires specialized apparatus to detect and study bats' orientation sounds. At the same time physicists and engineers, whether amateur or professional, have surprisingly little interest in animals that anticipated radar and sonar by 50 million years. If one percent of the ingenuity devoted by radio hams or hi-fi enthusiasts were brought to bear on improving and simplifying this sort of apparatus, bat-watching could become just as engrossing as bird-watching. But the partitions between scientific disciplines stubbornly resist erosion. Perhaps the World of Darkness may kindle enthusiasm in new generations for these wonders of zoology accessible only to those whose interests are not limited to a single scientific pigeonhole.

Echolocation is far more vital to insectivorous bats than serving merely as an emergency collision warning system. Consider the problem of locating and catching flying insects in the dark. At first it seemed inconceivable that echoes from mosquito-sized insects could be audible to bats. But a combination of laboratory and field studies dispelled this cautious skepticism. In 1951 when I first took the necessary apparatus out-of-doors to study wild bats while they were hunting insects on a summer evening, it was immediately obvious that each swoop and complex pursuit maneuver was accompanied by an increase in repetition rate of the orientation sounds. When these sounds were translated into the range of human hearing, the cruising patterns sounded like a slow *putt-putt-putt.* But at each insect pursuit, the translated orientation sounds speeded up to a rapid buzz. The tempo was reminiscent of a motorcycle, or an outboard motor, opened up from its slowest idling to full speed.

Another high speed photograph (below) shows the wing catch of a mealworm by *Myotis keenii.* The high speed photographs were taken by Frederick Webster with multiple flash intervals of one-tenth of a second.

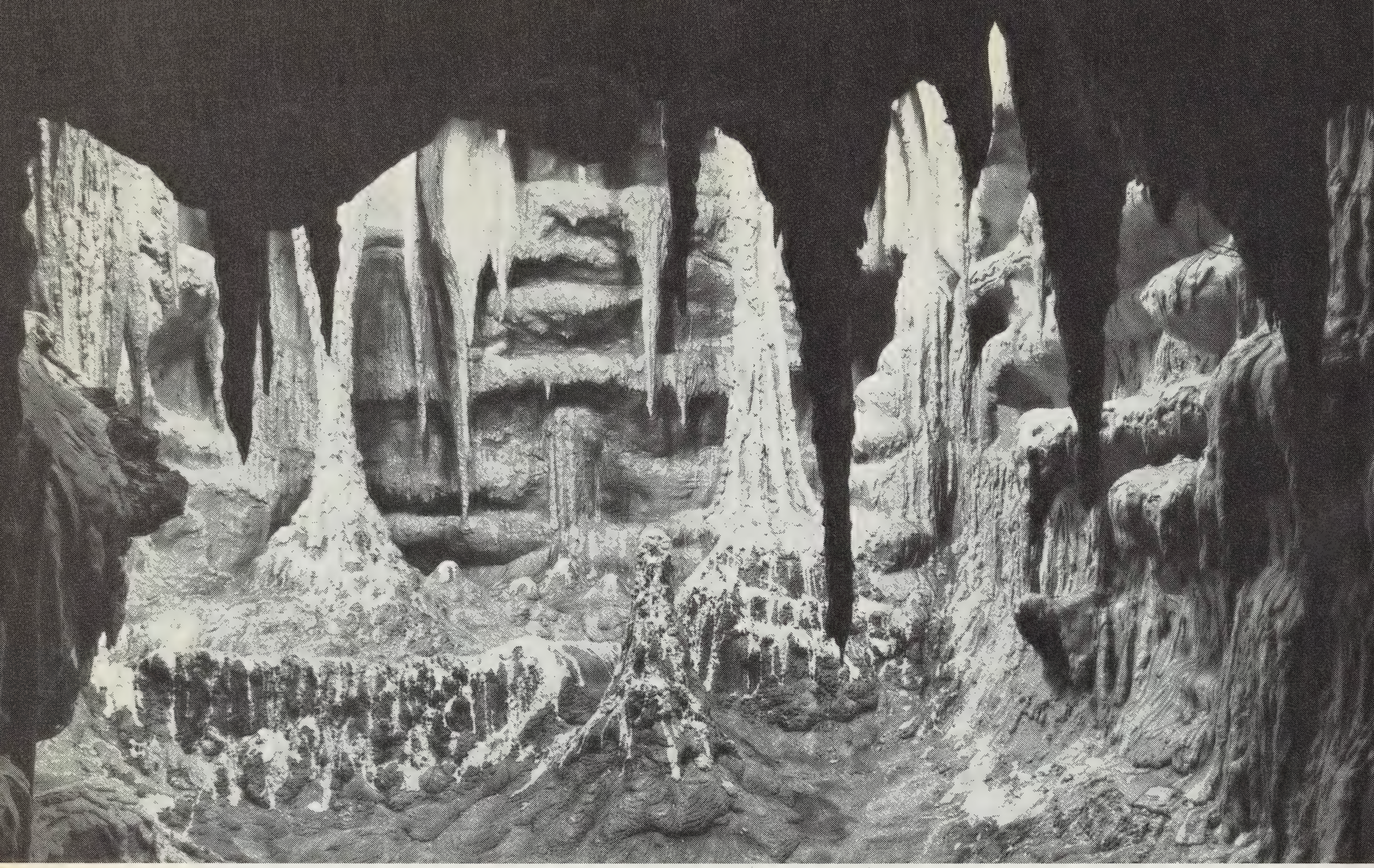


Further experiments showed that bats do indeed locate and capture small flying insects by echolocation. This is particularly striking with relatively silent prey such as midges or fruit flies. Loud buzzing insects such as blow flies and the larger flying beetles are also detected by the sounds of their wing beats. But insects that fly silently are rapidly and accurately located through the echoes of the bats' orientation sounds.

One of the most impressive aspects of bat echolocation is the speed with which information from echoes is analyzed in the tiny brains of these remarkable mammals. The flight of insect-catching bats appears wildly erratic, but actually the bat's gyrations are precisely executed pursuit maneuvers. Frederick Webster of Cambridge, Massachusetts, has obtained high speed photographs of insect-catching maneuvers along with synchronized tape recordings of the orientation sounds. These show that common little brown bats often catch several fruit flies per minute. Within a half-second one of these bats locates its prey, speeds up its orientation sounds, executes an elaborate pursuit maneuver on the wing, and swallows the insect. Sometimes the entire performance is repeated with another fruit fly within another second or two. When the hunting is good, individual insects the size of mosquitos or midges are selectively located and intercepted many times each minute.

Bats are also remarkably adept at discriminating important echoes, such as those from insect prey, against the confusing background of louder echoes from other objects at similar distances. Much insect catching occurs in wooded areas where leaves and branches return stronger echoes than the insect prey. Laboratory studies have shown that bats can dodge fine wires even in a loud jamming noise that blankets the frequency range of their orientation sounds. For a time our jamming experiments seemed to contradict what radar engineers call "signal detection theory." That is, bats appeared to detect echoes impossibly far below the level of the jamming noise. The bats had somehow failed to read the books on radar engineering.

Actually the solution to this paradox was very simple. It had seemed reasonable to assume that the air between a wire obstacle and the bat could be treated as a single communication channel. But bats have two ears, and their brains are well adapted to compare sounds entering through these two sensory windows. From comparisons of loudness, or from minute differences in arrival time of the same sound at the two ears, bats and other animals determine the direction from which sound waves reach them. When tested in a severe jamming noise our bats did more than this. They distinguished echoes from the interfering noise by



The tropical cave scene in the World of Darkness, modeled in fiber glass, sand, and resin after caves in Trinidad, is shown above quiet and empty; in the finished exhibit, bats will cluster among the dripping stalactites and present to the zoo visitor a glimpse of life spent in darkness.

flying in patterns that caused the noise and the echoes from fine wire obstacles to reach them from different directions. All of this may seem far removed from the esthetic wonders of supremely adapted animals sporting through complex flight maneuvers. But the real world of biology cannot be appreciated without recognizing both the natural beauty of animals and the elegant complexities of their physiology and behavior.

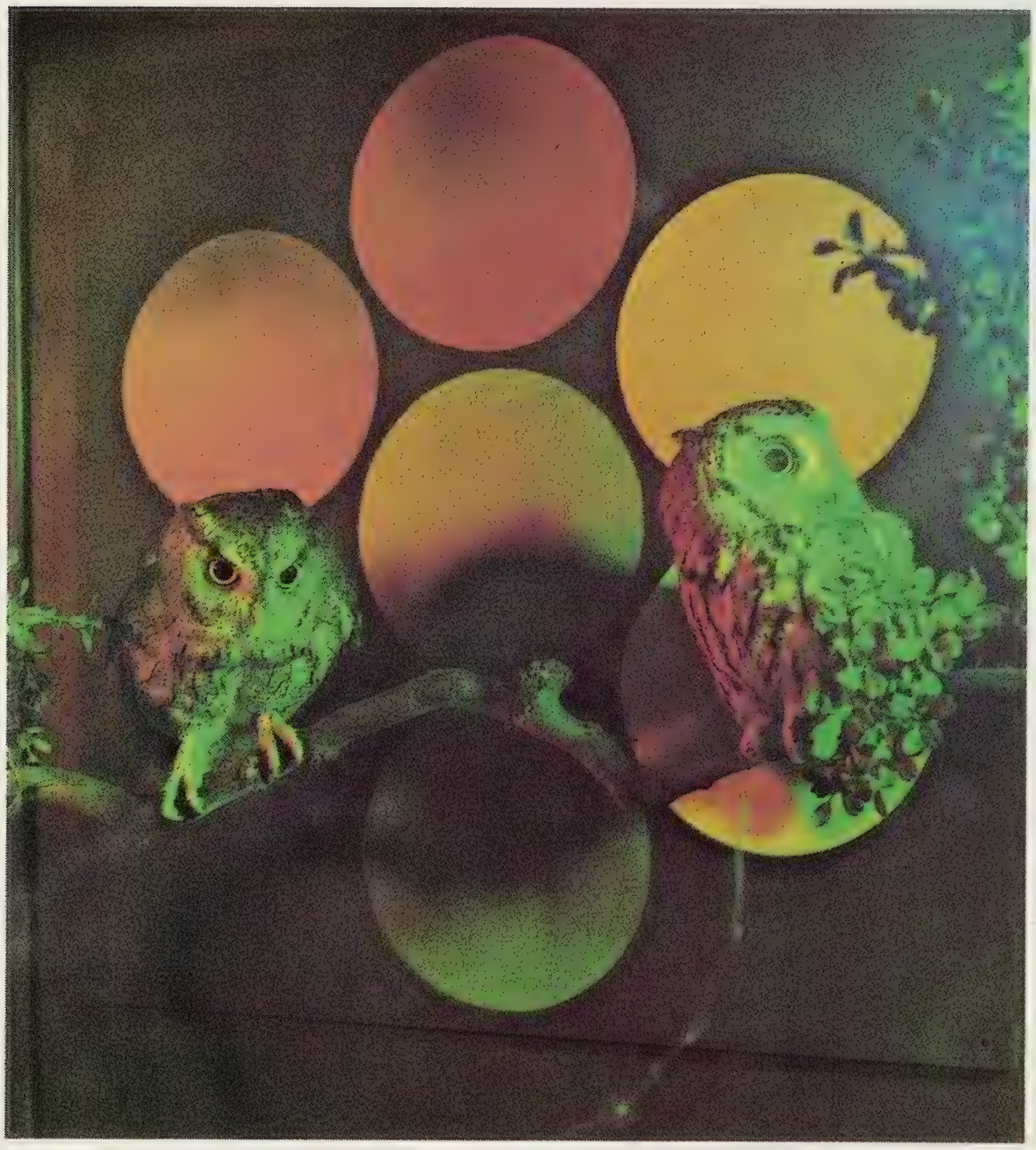
These admirably specialized flying mammals have still another message for our own species. Although we rely mainly on our eyes to keep in touch with our surroundings, disease or accident deprives many of our fellow men of this sensory window. Blind people are severely handicapped in many ways, but one of the most damaging aspects of blindness is a crippling reduction in the ability to get around in the world. Yet some blind people have managed to establish a new type of orientation through which they can detect and locate large objects before bumping into them. This is often known as "facial vision" because many blind people think they feel obstacles before contact. But it is actually echolocation. Many experiments have shown that the ability of blind people to detect objects at a moderate distance depends almost entirely upon sounds and echoes.

Despite many efforts to improve the ability of the blind to find their way about, human echolocation is far inferior to that practiced every night by millions of insect-catching bats. Why should this be? Why can't a blind man fly an airplane and catch pigeons over Times Square? Is it some special virtue of ultrasonic frequencies compared to the range of human hearing? Probably not, except for very small obstacles. Frequencies of sound at which human hearing is excellent have wavelengths only five or ten times longer than those used by bats to catch minute insects. Does the brain of bats have some special magic beyond our mental powers? Probably not, since the nervous systems of all animals seem to operate on the same basic principles. The entire brain of a little brown bat is less than one-thousandth the size of a human brain. What underlies its special talents at echolocation?

No other animal, regardless of its brain size, can recognize so many subtle complexities as we sort out in understanding speech or music. What is it about the "language of echoes" that allows a bat to succeed with one gram of brain where blind men fail and stumble with a thousand times more grey matter? The relevant scientific questions are unconventional, and hence neglected by all but a handful of experimental zoologists. Yet I am confident that answers will be found in time, and that these scientific discoveries will serve to lessen the handicap of blindness.

THE WORLD OF DARKNESS

Photographs by William Meng



OVERLEAF: "THE SWAMP" EXHIBIT.

AT LEFT: EASTERN SCREECH OWLS, "COLOR AT NIGHT" EXHIBIT.

BELOW, LEFT: NINE-BANDED ARMADILLO.

BELOW, RIGHT: PREHENSILE-TAILED PORCUPINE.

BATS FLYING IN SOUTH AMERICAN JUNGLE SCENE, "OUTSIDE THE CAVE."

ABOVE: AFRICAN BRUSH-TAILED PORCUPINE, "A FOREST FLOOR" EXHIBIT.

AT RIGHT: SLOW LORIS.

FAR RIGHT: KIT FOX, "THE DESERT" EXHIBIT.

ABOVE: TOKAY GECKO.
AT RIGHT: BRUSH-TAILED PHALANGER.

BELOW, LEFT: TAWNY FROGMOUTH. BOTTOM, LEFT: DOG-TOOTH CAT SNAKE. BELOW, RIGHT: LEOPARD CAT.

NORTHERN FLYING SQUIRREL.

LIFE AND LIGHT

BY DONALD F. BRUNING, ORNITHOLOGIST
NEW YORK ZOOLOGICAL PARK

For many years herpetologists puzzled over certain species of whiptailed lizards (genus *Cnemidophorus*), for it appeared that all individuals in these species were female. This was not, however, a complete certainty until Dr. Paul Maslin, curator of the University of Colorado Museum, resolved the issue by raising these lizards, from the egg, in complete isolation.

Dr. Maslin's work during the past few years has demonstrated that the species involved do indeed consist only of females and are truly parthenogenic, capable of producing offspring without mating. Parthenogenesis, while not uncommon in some lower invertebrates, is almost unknown in vertebrates, a fact which makes Dr. Maslin's demonstration particularly significant.

The Colorado scientist thus far has raised at least three generations of these lizards in total isolation. To accomplish this he had to overcome a difficult problem for which he found an easy solution. The lizards, Dr. Maslin discovered after a total lack of success in keeping the animals alive, require a small amount of longwave ultra-violet light if they are to thrive in captivity. Short daily exposure to a sunlamp supplied the needed ultra-violet and Dr. Maslin was able to proceed with his study.

The effect of ultra-violet light on the keeping of lizards is only one example of the way in which light affects living organisms, a fact that had to be kept very much in mind in preparing exhibits for the World of Darkness.

The full extent of the importance of light to animals in zoological parks was not fully realized until attempts were made to exhibit nocturnal animals by day. Most of these animals are naturally active only in darkness – or in zoos where activity-reversed exhibits are in use. Some successful attempts to show these animals while they were active took advantage of their inability to perceive red light. The animals were placed under red light in a dark room during the day and attempts were made to reverse their daily light cycle by turning on bright lights at night. This system worked quite well in getting the animals to be active and visible during the day, when sunlight otherwise would cause nocturnal animals to retire.

Sunlight is the ultimate source of all energy on earth; without it no form of life could exist. The sun is continually emitting energy as the result of the thermonuclear reactions occuring in its interior. The solar radiation—or energy—which reaches the surface of the earth consists of electromagnetic waves ranging in length from below 290 millimicrons to over 5,000 millimicrons.

All visible light lies between 380 and 760 millimicrons in wavelength and it is actually only a very small part of the full spectrum. The different colors of light are just the result of different wavelengths within this range of visible light. The ultra-violet portion of the spectrum lies below 400 millimicrons and grades down to the shorter x-rays

Whiptail lizards, such as the six-lined racerunner shown above, are diurnal; to thrive in captivity, they require a small amount of longwave ultra-violet light.

and gamma rays; above 750 millimicrons, wavelengths range though the infrared into the longer radio waves.

Longer ultra-violet triggers production of vitamin D in the skin, a process important for good health. All ultra-violet light, however, is not beneficial, even to female lizards; only longwave ultra-violet has the desired effect. Very shortwave ultra-violet can be harmful or even lethal to plants and animals – in fact, this property is utilized in germicidal lamps like those that barbers use to sterilize equipment. The Earth's atmosphere naturally filters out most of this harmful ultra-violet radiation, but anyone who has come home from the beach with a sunburned back knows all too well that some of the harmful ultra-violet reaches the surface of the Earth.

Sunburn is caused by shortwave ultra-violet, between 290 and 320 millimicrons, which is invisible. The skin is protected form sunburn by a natural mechanism which produces a pigment called melanin. Cells known as melanocytes produce the melanin and deposit it in the upper keratin layer of the skin where it serves to absorb ultra-violet light. The amount of melanin in the skin determines the darkness of the skin and is the

real basis for racial differences in skin color. Certain chemicals can sensitize the skin to other wavelengths of light which can result in severe sunburn without exposure to ultra-violet light.

Scientists are continually discovering more and more ways that light of all wavelengths and intensities affects animals. Rats kept under pink fluorescent light have a lower survival rate, produce fewer and smaller litters, and become more cannibalistic than rats kept under natural sunlight. This is but one example of how the "color" or the wavelength of light is important. Many other responses to the color of light are equally dramatic. Male mink are much more aggressive under pink light than under natural sunlight; but under blue light they become very docile and their reproductive rate increases.

Dr. John Ott of the Environmental Health and Light Research Institute of Sarasota, Florida, reports that chinchillas have an entirely different response: pink light leads to an increase in the percentage of male offspring while blue light increases the percentage of females.

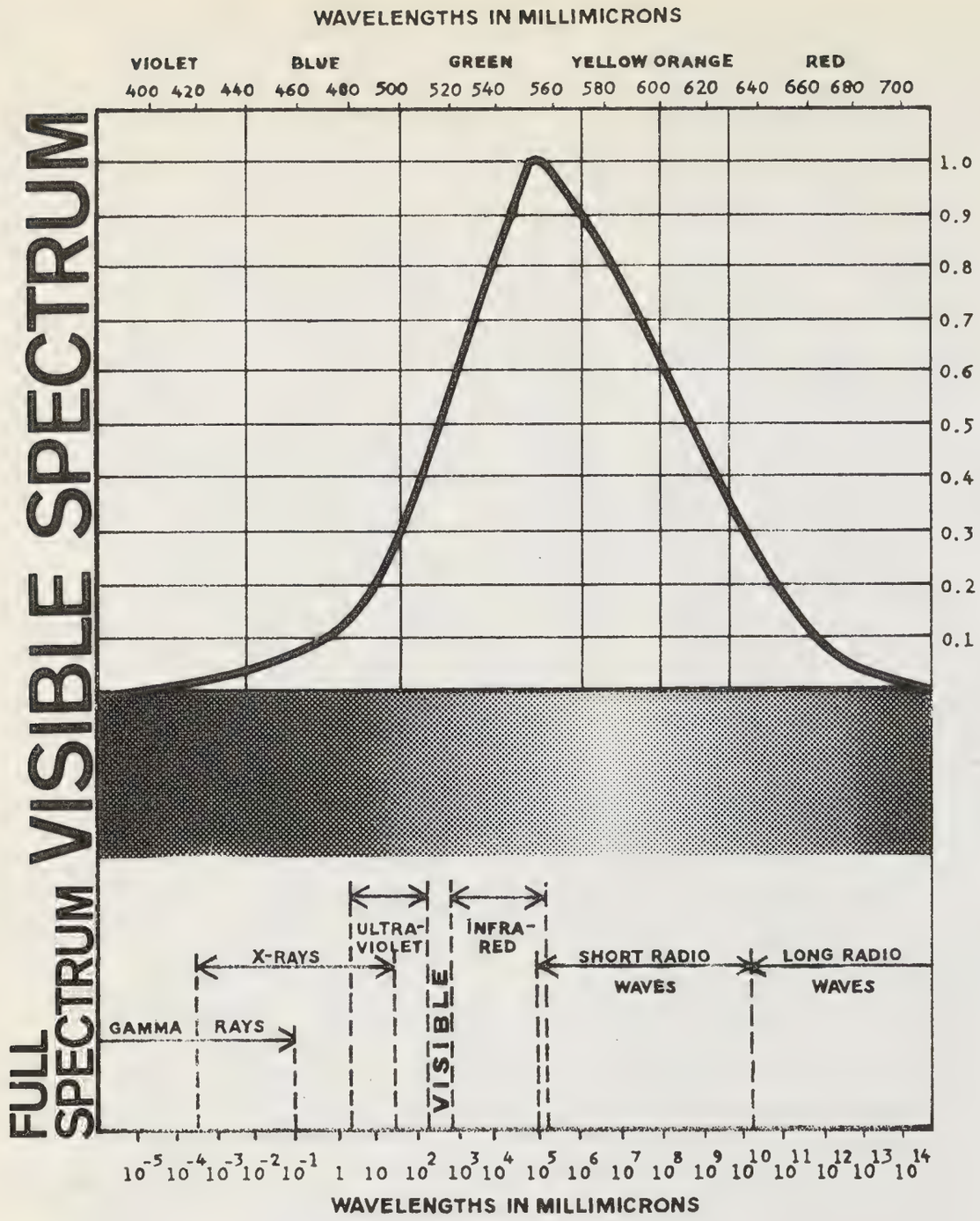
Researchers have found that other problems occur under unnatural lighting. Under pink fluorescent light one strain of white laboratory mice spontaneously develop tumors at a greatly increased rate. Mice under unbalanced lighting, either pink or blue, develop spots on their tails within three months and within six months they lose most of their tails.

Those little home aquarium fishes, guppies, normally produce an equal number of male and female offspring under natural light, but under pink light they produce 80 percent females, and the few males show retarded development. Other guppies under blue light produce 80 percent males.

Nor are humans immune to the effects of light of various color and composition. Human beings working under pink fluorescent lighting become more irritable and more susceptible to illness than those under natural light. These examples could be multiplied to show differing effects of differing light on mice and chickens. Another key to understanding some of these effects of light is a realization that it is probably not the color or wavelength that is present that causes some effects but it is more likely the absence of other wavelengths that is important.

The tokay gecko of southeastern Asia is a nocturnal lizard, thus presenting entirely different problems and requirements for its exhibition.

Recent findings have helped explain how light can cause these various responses in man and animal. Light enters the eye and strikes the rod and cone cells of the retina. The rod cells are not sensitive to colors but perceive black and white only. The three types of cone cells, each containing a different pigment, are sensitive to color. One pigment absorbs red, one blue, and one green. The cone cell upon absorbing a color of light sends an electrical impulse down the optic nerve to the brain. At this point, a person realizes the color he has seen, but that doesn't end the story. Connections are made within the brain to the endocrine



The total spectrum is shown on the lower portion of the chart above. At top is an expanded section of the visible spectrum, along with a graph showing the sensitivity of the human eye.

system and these can result in a physiological or a psychological response to the color or intensity of the light.

The full spectrum seems to be essential for most animals. Ultra-violet light is a special case, as it can be harmful or beneficial at different wavelengths.

Most light bulbs are designed to produce a minimum of ultra-violet light but a form of fluorescent bulb was developed some years ago to provide ultra-violet light for plants grown indoors. These lights have adverse effects on animals exposed to them for long periods. Rats and mice, for instance, lose their tails and their fur if kept under them. Gradually the realization is growing that it is not ultra-violet light in general that is harmful but specifically the shortwave ultra-violet; longwave ultra-violet is at the least beneficial, and to most animals and plants it is essential.

Warren Zeiller of the Miami Seaquarium found that a viral disease called "popeye" seldom occurred in fish which had natural sunlight but was very common in certain fish kept under artificial lighting. Mr. Zeiller then found that even a 15 minute exposure to ultra-violet light each day not only prevented most cases of "popeye" but also cured most existing cases. The ultra-violet light helped speed healing of injuries and diseases and increased the longevity of many captive fish.

Fortunately a considerable variety of illumination sources, particularly fluorescent bulbs, that produce differing qualities and quantities of light are available. The problem then, at least in part, is adjusting the light to the animal to be exhibited. The length of day may, depending on the organism, regulate daily activities, seasonal migration, breeding, and many other internal and external activities. Many other responses are also controlled by the day length. Seasonal color changes in some birds and mammals, metamorphosis in insects, and growth and flowering in plants are just a few examples of this control.

The effect of the day length on both plants and animals is most pronounced in species from temperate and arctic areas where there is a seasonal change in the day length. Most tropical animals are not adapted for seasonal variations, because the length of the tropic day varies little during the year. Therefore, it has no regulating affects on them. Changes in day length can disturb these tropical animals and they do much better in captivity if they receive their natural 12 hours of light and 12 hours of darkness.

Dr. Richard Penney at the Institute for Research in Animal Behavior of the New York Zoological Society and The Rockefeller University has been able to successfully breed and raise captive Adelie penguins *(Pygoscelis adeliae)* by maintaining them at temperatures and day lengths that simulate those of the antarctic breeding grounds of these birds.

Tufted puffins *(Lunda cirrhata)*, pigeon guillemots *(Cepphus columba columba)*, and rhinoceros auklets *(Cerorhinca monocerata)* all attained a more natural coloration after a new lighting system was installed in their sea cliff exhibit at the Bronx Zoo. After not displaying breeding behavior for four years in their exhibit, all of these birds showed interest in breeding within a couple of months after the new lighting system was installed; one pair of tufted puffins, in fact, produced a fertile egg. (Unfortunately the egg, which contained a fully developed embryo, was rolled out of the nest just two days before it would have hatched.)

The lighting system in the exhibit not only controlled the day length by means of a time clock and a dimming device, but it also included a new type of fluorescent bulb which produces a spectrum quite similar to natural sunlight, including the ultra-violet.

The problems of lighting in exhibits are many and complex, and the lighting system in the World of Darkness has been planned for maximum flexibility in the hope of meeting future problems as they arise. The goal is to provide enough illumination for the public to view exhibits while insuring sufficient and healthful light for the animals.

AND THEN THE ANIMALS...

AFTER AN EXHIBIT HAS BEEN PREPARED, THE ANIMALS MOVE IN

BY HUGH B. HOUSE, CURATOR OF MAMMALOGY
NEW YORK ZOOLOGICAL PARK

How do you induce flying squirrels to "fly"? These small rodents, superbly adapted to a life of darkness, can live very intimately with man and may only rarely be seen, and a person must be extremely fortunate, indeed, to see them in flight. It is more accurate to say that they glide but, regardless, it is a most delightful and interesting phenomenon. When the New York Zoological Society's mammalogy department planned its exhibits in the World of Darkness, we greatly wanted to design an exhibit that would at least occasionally induce the squirrels to launch themselves into

space and give the spectator a glimpse of the creature's otherwise inconspicuous flight membranes.

The problems of providing a somewhat natural setting for and inducing activity from living animals in captivity are varied and call for ingenuity, perseverance, no little luck, and completely unpredictable animal cooperation.

It is one thing to provide for an animal's needs and another to persuade it to put its best foot forward and demonstrate its uniqueness for the zoo visitor. Because many of the exhibits in the World of Darkness are unique, the problems involved in displaying animals are magnified.

What animal species do you select to exhibit? Where or how do you get them? What are the animals going to do? How will they respond to your efforts – your attempts to predict based on your experience and intuition? In forming the assemblage of animals to be representative of the nocturnal world, an effort was made to give as broad and representative a picture as possible.

A basic exhibit technique in the World of Darkness is to induce exhibit animals to change

A flying squirrel glides in for a tree-landing in the forest (see page 21), but will the flying squirrels "fly" in the World of Darkness? Will the terrestrial little spotted skunk (opposite page) keep the squirrels off the ground in their mutual exhibit? Meanwhile, in the desert scene, will the extremely shy and fastidious kit fox (above) get enough to eat? Or will it be nosed out by its neighbors, the hog-nosed skunk (at right) and the armadillo (see page 25)? These are only some of the questions that will be answered by the animals themselves as they settle into their habitat exhibits in the World of Darkness.

the active phase of their daily cycle to coincide with visiting hours at the zoo. Controlling light levels attains this result with most animals. In addition, we take advantage of their color blindness and flood exhibit enclosures with dim colored light, which is invisible to our animals, although visible to humans.

To get our squirrels to fly seemed simple enough – give them a long narrow exhibit with a denning area at one end and a feeding station at the other end. Flight would seem to be the quickest route between the two points, but in practice the squirrels were as likely to elect a more indirect and leisurely route across the exhibit floor, with side excursions here and there, than take the unobstructed course through thin air. The problem then became how to keep them off the display's floor. The solution here was to introduce another animal that might discourage floor activity but yet not pose a dire threat to the squirrels. The spotted skunk was our choice, and a plump little female and her litter of three youngsters were moved into the exhibit.

The squirrels have plenty of branches for aerial exploration and activity, but a gap in the "treetops" best negotiated by flight remains. The skunks have their own dens and ample floor space. Muskrats were placed in the same exhibit in expectation that they would back up the skunks as squirrel deterrents. The muskrat is remarkably pugnacious and antisocial for an overgrown aquatic field mouse, however, and these rodents could prove to be incompatible with their neighbors in the exhibit and therefore are watched closely.

In predicting an animal's response to a given situation, we are dealing with the nature of the species in general and the nature of the individual in particular. It is a fairly safe assumption that hog-nosed skunks, armadillos, and kit foxes rarely come into dispute in the deserts of the southwestern United States, but how will these same species behave when they come into frequent close contact in a zoo's desert exhibit? In order to find the answer, we put these animals together and observed them, but to improve the chances for compatibility, we used young animals in hopes that babies would be more adaptable to a common existence. The result was a group of mixed species but compatible animals.

In captivity these three species could be graded on two different scales: one, messiness and the other, gluttony. The foxes ranked consistently high or low depending on one's point of view. They were not only fastidious in manners but showed no inclination to over-eating and related obesity. The skunks nosed out armadillos on the gluttony score but had to give way on messiness. These varying characteristics could pose real exhibit problems – the foxes could manner themselves into malnutrition while the skunks and armadillos ate themselves into corpulency.

Fortunately, on yet a third scale – nimbleness, the foxes ranked high. It was possible to give the foxes a retreat where they could get a proper diet and a degree of privacy which would be inaccessible to skunks and armadillos. This also made it possible to control the amounts eaten by the latter without decreasing the amount of food given to the foxes. Each species had its own retreat constructed to our concept of what it should prefer.

All exhibit planning is based on concepts of what an animal either will or will not do or need. These concepts in turn are based on experience with animals and curatorial intuition. If somehow an animal responds as we predicted, we congratulate ourselves on our perspicacity; if not, we skulk back to the drawing board.

One of the more ingenious exhibits – the two replica cages showing day and night phases simultaneously with day and night animals in each – at least temporarily backfired. The exhibit was set up in the small mammal house to see how successful it would be. The animals involved were flying squirrels, nocturnal and arboreal, and chipmunks, diurnal and terrestrial. Theoretically, they were supposed to sort themselves out in space and time which they did most gratifyingly, at first. All went well until a female chipmunk deserted her terrestrial burrow and chose to take possession of the arboreal nest of the flying squirrel. She promptly gave birth to and reared five babies on full view to the delighted public. It remains to be seen whether these five youngsters will suffer adjustment problems due to the whim of their mother. It has to be admitted that in a small exhibit the distance between terrestrial and arboreal abodes makes confusion understandable.

The exhibits in the World of Darkness were built to withstand the everyday wear of animal use and cleaning operations. The effects of animal use vary with the kind of animal exhibited. Birds and reptiles generally are not too destructive in a exhibit situation, while mammals give us ample trial of techniques and materials.

The exhibits as they appear in this new building only suggest the potential that exists. We look at them as something which will evolve. As we learn more from the animals, we will find new ways to reveal these things to the visitor. Exhibits will change and new species will be introduced to give a more comprehensive view of the nocturnal animal world.

The nine-banded armadillo (opposite page) relies for protection in its plates of armor and the surprising agility with which it can reach the safety of its burrow.

BLIND CAVE FISHES

BY ROBERT A. MORRIS
CURATOR, NEW YORK AQUARIUM

My first introduction to fish without eyes came 11 years ago in Hawaii where I stared in amazement at a tank of Mexican blind cave characin *Astyanax jordani.* The United States Fish and Wildlife Service was studying the feasibility of using these pink, eyeless fish for tuna bait. I placed my hand in the tank and the blind fish swam between my fingers without touching me. Since that time I have observed many people gazing at the exhibit of Mexican blind cave fish at the New York Aquarium and asking such questions as "Why are they blind? Why don't they bump into the cave wall? How do they find food?"

Blind animals are found in every class of vertebrates except birds. It is estimated that, counting the deep sea forms, 78 species of fish have eyes which are reduced or absent. These sightless fish range in diversity from cyprinids (carps and carp-like fishes) to the soles (flatfish). An estimate of the numbers of sightless fish that inhabit caves is very difficult. Much depends on the definition of a cave. New species of blind fish are being discovered every year. The fact that they live in obscure niches makes them hard to collect and consequently to discover. A reasonable estimate of the number of blind cave-dwelling fish might be 25 to 30 species.

Cave fishes in general can be divided into three groups:

Troglodytes; species which only inhabit caves. These forms have degenerate eyes and little or no pigment.

Troglophils; species which inhabit caves but may also occur elsewhere. These forms may have reduced eyes and reduced pigment formation.

Trogloxenes; species with a wide distribution but which may be accidental or voluntary cave entrants. These fish have normal eye development and normal pigmentation.

Usually associated with the troglodyte, or blind cave dweller, is an "epigean" (above ground) species that may be considered an ancestral relative of the blind form. These fish are sometimes similar to the blind form, differing only in having eyes and pigmentation.

One of the most frequently studied blind cave fish is the Mexican blind characin *Astyanax jordani.* In 1936 this fish was the first reported blind fish from Central America. The New York Aquarium was one of the first institutions to receive and exhibit these specimens. Such scientific interest was aroused that in 1940 the aquarium sent an expedition to Mexico to photograph, to study, and to bring back specimens. Much to the surprise of everyone, the collectors found a complete series of fish from the pink eyeless forms to those with normal eyes. The farther the fish were from light source, the more regressive the characters; those with no eyes and pink coloration were found in the darkest part of the cave. The epigean ancestor, *Astyanax mexicanus,* of the blind form was also collected from waters outside the caves, the only difference between this fish and the blind fish being the presence of eyes and pigment.

Unlike many other blind cave fishes, the Mexican characin proved easy to breed and to maintain in captivity. This has allowed detailed studies of its behavior and genetics. Experiments on this fish have demonstrated possible mechanisms involved in its origin.

First, it was found that blind specimens prefer red darkness if given a choice. Light may be perceived by the incomplete remnants of the optic nerve. Both the river forms and the blind forms are positively rheotrophic, that is, they will swim against a current. Both river fish and blind fish are also positively thermotrophic; they can detect water temperature differences as little as 1.5 degrees F. and seek warmer water. It was also found that the river characin *A. mexicanus* has variations in eye size.

A theory may now be advanced to explain the evolution of these fish. The eyed river forms *A. mexicanus* found themselves in the river leading to the caves. They prefer darkness, warm water (it is believed that the water in the cave is warmed by layers of molten rock that come unusually close to the surface in this area), and swim against the current. They now enter the cave, which is upstream. All these factors tend to keep the fish in the cave. The genetic tendency toward eye size variation would now come into effect. Fish with normal eyes are favored by selection; predators easily capture fish with poor eye development, and food seeking is hindered.

Once in the caves, however the fish have no predators, and eyes are of little use in obtaining food. The selection for normal eyes is relaxed and genetic mutations resulting in smaller eyes are perpetuated through interbreeding. Smaller eyes result until they eventually disappear. The pinkish coloration frequently found in blind forms is due to lack of melanophores, or pigment cells. Blood shows through the skin, resulting in a pink color.

Food supply for Mexican blind fish is plentiful. Currents carry food into the caves. Droppings from insectivorous bats within the caves are readily eaten by the fish.

The amblyopsid fishes from limestone caves of central United States are another group of fish which have been extensively studied. These are small carp-like fishes which were first described from Mammoth Cave, Kentucky, in 1842. Five species are involved in this locality, plus an epigean ancestor which occurs in the swamps of the southern Atlantic coastal plains.

At some time during the tertiary period (40 million years ago), the ancestors of the *Amblyopsis* entered the ground water of the limestone plateaus and were dispersed through subterranean channels below the water table.

Northern cave fish *Amblyopsis spelaea,* Ozark cave fish *Amblyopsis rosae,* southern cave fish *Typhlichthys subterraneus,* and a yet unnamed *Typhlichthys* are the four blind species (troglodytes.) The spring cave fish *Chologaster agassizi* is not blind but has reduced eyesight (troglophil). This species is not restricted to caves but found in spring systems. The ancestral swampfish, *Chologaster cornuta,* is fully eyed and pigmented and does not frequent caves.

Several adaptations to the cave environment are evident in the blind amblyopsids. Sensory cells called neuromasts are present in a canal – called the lateral line – along the sides of many fishes. These neuromasts have hair-like projections which are surrounded by a gelatinous material. The canals penetrate the scales through a pore to the exterior. Low frequency vibrations and pressure waves, created by the fishes' movement through water or movements of solid objects under water, act upon these neuromasts, notifying the fish of such movement.

The Kentucky blind cave fish have fully exposed neuromasts which are grouped in ridges on the head and body surface thereby increasing their sensitivity to objects. Increased length of pectoral and caudal fins enables the fish to silently "glide" through water thus reducing interference noise to their neuromast receptors. *Amblyopsis* will reduce speed when obstacles are 10 inches to 16 inches ahead and avoid them at a distance of 4 inches to 6 inches. Prey location is also acute. A minute water flea measuring an eighth-of-an-inch may be detected at a distance of nearly two inches. A high survival rate of young cave fish is insured by incubation of the eggs and yolk sac fry in the adult's gill chambers. This incubation period may last from four to five months.

Endocrine adjustment must take place in order for the fish to survive in the dark. It has been demonstrated that the epigean ancestor, the swampfish, of the Kentucky blind cave fish is not adapted to underground living. When kept in the dark for long periods, these fish develop endocrine imbalance which results in skeletal deformities and pituitary degeneration.

Blind fishes from the family Brotulidae are found in freshwater caves in Cuba. These are represented by two species, *Stygicola dentatus* and *Lucifuga subterraneus.* The eyes decrease in size progressively from birth to extreme old age, and eye muscles degenerate and are entirely absent in old forms. The lens of the eye, in fact, starts degeneration before birth. High survival rate for the young is insured by viviparity (giving birth to live young). Well developed sensory cavities are present on the head.

Typically, brotulids are salt-water forms that range in distribution from the shallowest to the deepest depths. They are known to prefer dark habitats. The ancestors of the blind freshwater species most probably lived in crevices in the Cuban coral reefs. As the lands were elevated to their present and greater heights, adaptation to the freshwater environment took place. The waters of the freshwater caves are high in salts of lime and magnesium and this probably made adaptation to freshwater easier.

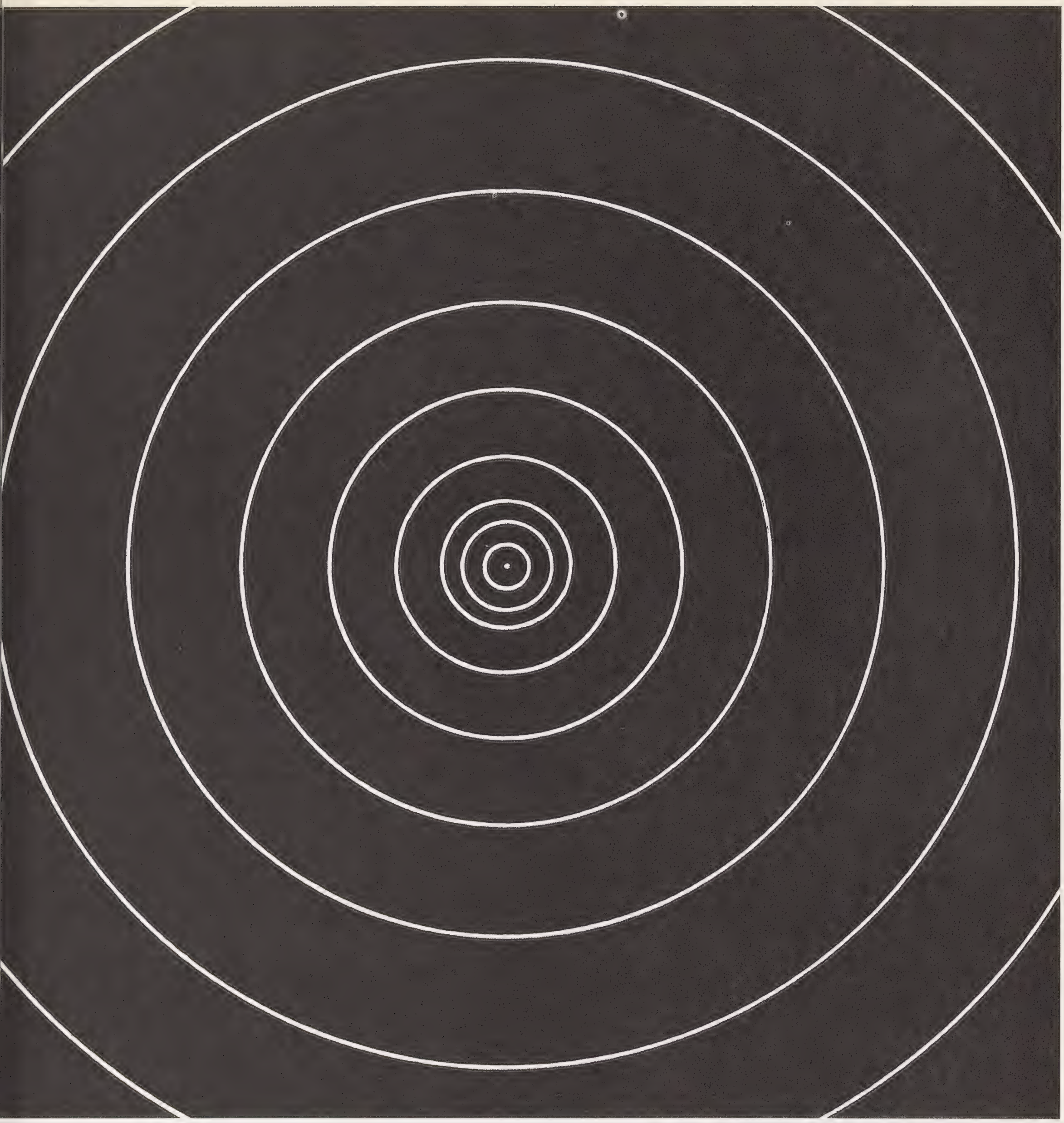
The blind, colorless goby, *Typhlogobius californiensis,* from the intertidal region along the southern California coast has a fascinating life history. This goby is found living in burrows, (which may be classified as caves) in a commensal relationship with a shrimp, *Callianassa affinis,* which is also blind and colorless. The shrimp dig burrows and live in the outermost area, while the gobies live in pairs within the burrows. Circulatory water currents set up by the shrimp furnish food and oxygen for the blind gobies. Death of the pair of blind shrimp results in the death of the gobies, resulting from the absence of current flow. The life span of these fish and shrimp is 10 to 12 years.

The goby's adaptation to cave life is demonstrated by lack of scales, reduced dorsal spines (not needed in caves), highly sensitized skin (neuromast development), and tactile papillae around the mouth, increasing touch reception.

Many other blind cave fishes have interesting life histories and are equally adapted to cave life. It is difficult to generalize on the origin of such diverse groups, but several factors emerge from studies. Biologists feel that most, if not all, of the blind cave forms were "preadapted" to cave life before entering that particular environment. Such prerequisite adaptations might be behavioral or physiological patterns that encourage cave entrance: response to current, temperature, light; possession of necessary sense organs to allow cave survival, such as touch receptors and neuromast development; a tendency for eye size mutations; endocrine adjustment; selective parental care; lower metabolic rate (advantageous for those fish with scanty food supplies); and better integration of sensory information.

This "preadaptation" of the eyed ancestral cave form is no doubt necessary for further development or regression of that particular species to an eyeless non-pigmented fish.

The problem is interesting and complex and will be studied for years to come.



Adaptations for Nocturnal Survival

BY WAYNE KING, CURATOR OF HERPETOLOGY
NEW YORK ZOOLOGICAL PARK

The small tadpoles of the red flying-frog *(Rhacophorus pardalis)* fell one after another from the meringue-like foam nest on the shrub into a small pool of water 10 feet below. The patch of liquid was only the size of a dinner platter, but not a single tadpole failed to find the watery target.

The red flying-frog lives in the rain forests of Sumatra, Borneo, and the Philippines. It and some species of rhacophorid frogs beat the gelatine coating of their eggs into a frothy nest at the time they are laid and attach the sticky egg mass to the leaves of a tree or shrub. The tadpoles that hatch from the eggs drop into the water below, where they live until they metamorphose into adult frogs.

If the nest is not placed exactly over the water or if the tadpoles fall on dry ground, the hatchlings will desiccate and die. This makes the entire

nesting process an extremely challenging engineering feat for a frog only two to three inches in body length. To reach the correct spot over the puddle, the breeding frogs might have to move away from the water to the trunk of the tree. After climbing the tree the small amphibians may then have to traverse the limb to a position over the water. This might not sound too complicated, except that the whole process takes place at night, and pinpointing a puddle of water somewhere far below in the dark is no easy task.

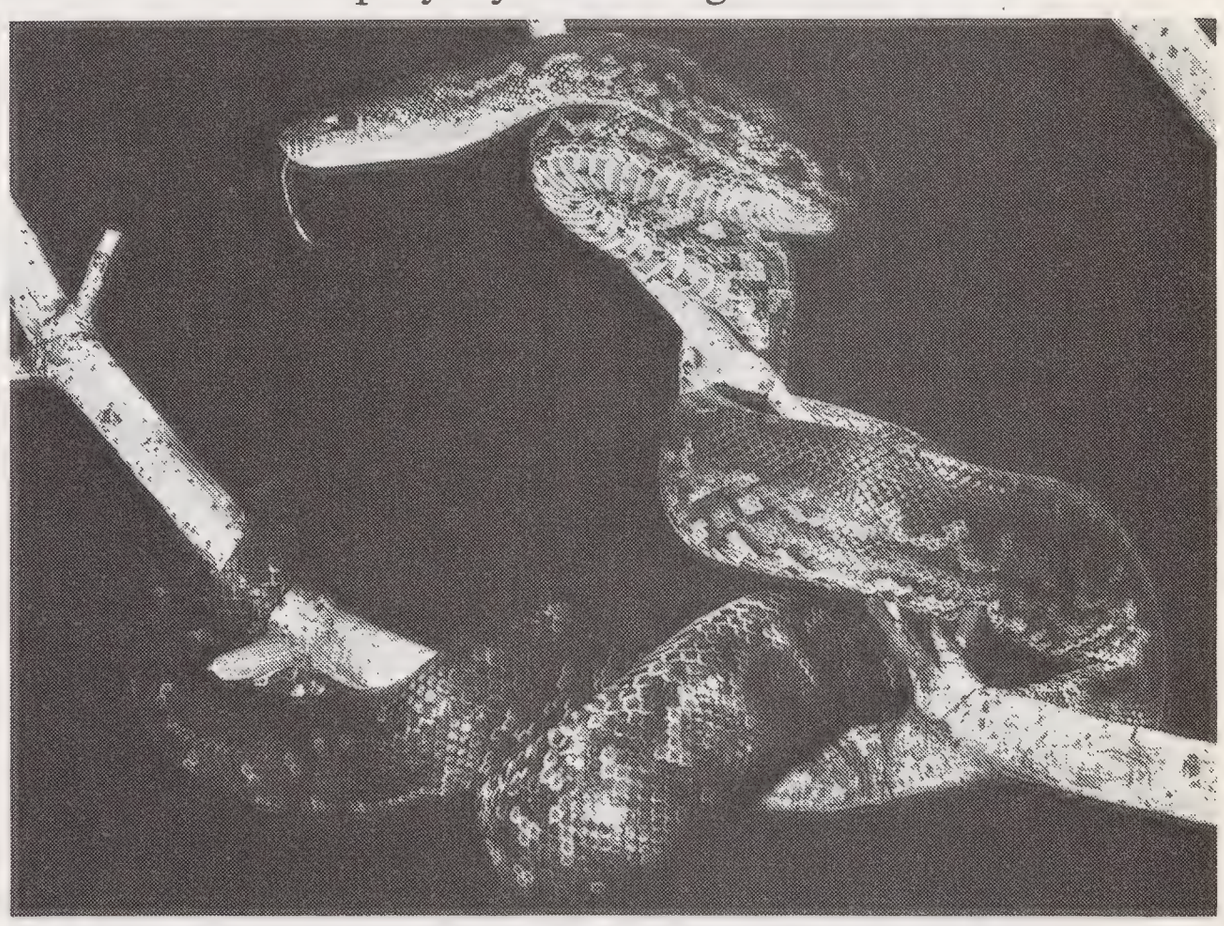
This points out only one of the many kinds of problems that darkness imposes on nocturnal amphibians and reptiles, problems such as finding or capturing food, locating a mate, and avoiding predators. Evolution has provided numerous solutions to these problems by enhancing or modifying the sense organs of the nocturnal species.

Many nocturnal amphibians and reptiles have large sensitive eyes that enable them to use effectively the dim light available on clear nights or during twilight hours. And many have horizontally or vertically elliptical pupils. These can close to a mere slit, preventing excess light from damaging the retina during the day, and open wide, permitting passage of as much as possible of night's low-level light. Alligators *(Alligator mississippiensis),* Malayan bent-toed geckos *(Cyrtodactylus malayanus),* cat-eyed snakes *(Leptodeira annulata),* and many New World and Old World treefrogs *(Hyla* sp. and *Rhacophorus* sp.) have this type of eye structure.

Some burrowing and trogolodytic reptiles and amphibians live in perpetual darkness, where vision is of no advantage and where they must rely on other senses to survive. The European olm *(Proteus anguinus),* the Texas blind salamander *(Typhlomolge rathbuni),* the Georgia blind salamander *(Haideotriton wallacei),* and the Ozark grotto salamander *(Typhlotriton spelaeus)* are examples of such animals. Each has lost its vision through degeneration of the eye or decrease in its size. The eye of the olm larva never advances beyond an early stage of development, while the larva of the grotto salamander develops fully functional eyes. However, when the grotto salamander larva metamorphoses into an adult inside the lightless cave, the eyes degenerate and become overgrown with skin. If the larva is kept in the light during metamorphosis, the eyes remain functional in the adult.

Nocturnal frogs, toads, and geckos rely heavily on vision to find and identify prey. Movement seems to be an important visual factor in discriminating food from non-food items, for almost anything that is relatively small and moves is eaten by these animals. Even so, there are many nocturnal species, particularly toads, that can locate food by means of smell almost as easily as by vision. The natterjack toad *(Bufo calamita)* of Europe and the giant toad *(Bufo marinus)* of tropical America can identify food by smell alone; occasionally these creatures will gather around garbage dumps at night to feed on discarded table scraps.

A keen sense of smell enables many nocturnal snakes to locate prey by following scent trails. All



The Haitian boa has heat sensitive pits in its lips which enable it to catch bats in dark caves.

snakes and lizards have two pits in the roof of the mouth which contain many sensitive cells similar to those that line the nasal cavity. The pits, called Jacobson's organs, are connected to a branch of the olfactory nerve. When the tongue is protruded, it picks up minute particles from the air, ground, food, and other nearby substances. The tongue is drawn in and inserted into the pits where the particles are smelled or tasted. The familiar in and out flicking of the snake's tongue attests to the nearly constant use of the Jacobson's organs.

Some snakes possess a special sense organ that detects the body heat (infrared waves) from prey animals. One group of poisonous snakes, the pit-vipers, derived their common name from the sensory pit located between the nostril and eye on each side of the head. This pit is supplied with numerous nerves sensitive enough to detect differences of as little as 0.2 degrees C.

Many pythons and boas possess similar heat receptors between the scales of the lips. Where pit-vipers have a single pair of pits, however, pythons and boas usually have numerous pits. The pits enable the snake to find and strike warm prey. What may well be the most dramatic demonstration of the use of the pits occurs in the dark ledges and interior passages of the bat caves near Trinidad, Cuba. There in the blackness the Cuban boa

Heilprin's tree frog, native to the West Indies, climbs with the aid of suction pads on its toes (opposite).

(Epicrates angulifer) stalks the bats that form a major part of its diet. Some bats are struck as they sleep hanging from the ceiling, but others are caught on the wing as they fly through the cave. Even though the cave is dark, the boa's sensitive labial pits enable it to locate and intercept the airborne bats.

Some nocturnal or fossorial snakes use their Jacobson's organs and special sense of small to locate a mate. The small eastern ringneck snake *(Diadophis punctatus)* is one such animal. It lives under logs, or under the loose bark of trees, and is seldom seen above ground in the daylight. The odor of the soil under the log changes when the snakes void their cloacal glands or digestive tracts, and this odor attracts others of their kind. In fact, the drawing power of this scent has been demonstrated in the laboratory by transferring soil from under a log that has sheltered ringneck snakes to beneath a log that has not; ringnecks soon congregate under the second log.

Males of nearly all frogs and toads attract females for mating by means of vocalizations or calls; these vary from the delicate tinkle of many West Indian free-toed frogs *(Eleutherodactylus* sp.*)*

Puffed in song, a Fowler's toad adds its mating call to the evening air.

to the guttural snorts of the pig frog, or southern bullfrog, *(Rana grylio),* to the high-pitched trill of the red-spotted toad *(Bufo punctatus)* of southwestern North America.

In the tropics, where many amphibians breed year-round, frogs may call singly or in small groups, but in the temperate zones, where cold or dry seasons confine breeding to warm, wet times of the year, groups of calling males may number hundreds of individuals. These choruses can be heard from a great distance, and within certain limits, the louder the chorus, the greater the distance from which it will attract females.

It is possible in northern Florida to hear as many as 15 different species of frogs calling from a single chorus. Having females of 15 different species coming to the same pond to breed could result in frequent mismatings if it were not for the fact that each female is attracted only to the call of her own species.

Frogs and toads depend on a keen sense of touch or feel to avoid potential predators. Almost every person who has collected frogs at night has experienced the frustration of having an intended specimen leap away when a careless step spread a fan of ripples through the water to lap at the frog in warning. But while it frustrates the collector, the sense of touch assures that frogs will survive. Similarly, salamanders feel vibrations from the substrate in their front legs; snakes feel them through the ventral surface.

Many nocturnal amphibians and reptiles also depend on vision to identify predators. Just as small moving objects seem to signify food to many frogs and toads, large moving objects are avoided as potential predators, especially when those objects are silhouetted against the night sky.

Some amphibians, such as Hose's frog *(Rana hosei)* of southeastern Asia, use a smelly and poisonous skin secretion to ward off predators. The skin of this frog is so poisonous that it will kill other species of frogs placed in a container with it. It also has a distinctive odor that humans can detect from several feet away. Most predators will not attack Hose's frog; if they do bite the frog and survive, they become so sick that they will not again attack a frog with a similar smell. The lesson is learned by humans as easily as by other predators, for any person who absent-mindedly rubs his eyes after handling these frogs has the smell etched in his memory by the burning pain and eye inflammation that follows.

Sound plays an important role in establishing the territory of nocturnal reptiles and amphibians. Male crocodilians bellow during mating season to establish or advertise their territory and possibly to attract females for mating.

One large group of lizards, the geckos, are nocturnal and are vocal as well. One of the memories that persons traveling in the tropics frequently return with is the soft cluck or chatter of geckos inhabiting the cracks and crevices in the walls and ceilings of their hotels. These vocalizations may serve as an announcement of territory, since they frequently precede a fight between adjacent animals.

The problems of survival in a nighttime world are many. Evolution has provided the nocturnal amphibians and reptiles with many solutions which enable them to exist in that world of which mankind is only dimly aware.

DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

The Aye-aye

Daubentonia madagascariensis

A demon bent on the downfall of man, if discovered in a state of temporary helplessness, can expect no mercy from his potential victim. The aye-aye, a nocturnal primate of the island of Madagascar of the Malagasy Republic, had that label bestowed upon it by superstitious men, and today, as it faces oblivion, it can count on no help from the inhabitants of that island.

The aye-aye in Malagasy folklore is an evil being, carrying with it bad luck and death. Formerly, superstitious villagers protected the animal, in hopes of staying within its good graces. Today, emboldened by a smattering of sophistication, the self-designated "victims" of the aye-aye kill the animal at every chance.

Officially the Malagasy government has protected the aye-aye, along with most of its lemur cousins, but official decrees mean nothing to a man who sees spooks in every shadow. Few, if any, species face extinction creeping up in so bizarre a way. The pressures on the aye-aye come in more mundane guise as well, in the all too common form of ruination of needed habitat, and this is perhaps the major threat to the strange primate.

The aye-aye is the only living representative of the family Daubentoniidae and is restricted to the forested areas of part of the east coast of Madagascar. It is about the size of a large house cat, but it looks like neither a cat nor even a primate for that matter. Its face proper has something of a resemblance to that of a potto, short and thick of snout, but its ears are very large and membranous, and its teeth are rodent-like.

The third finger of the aye-aye is long and slender and is used to hook the larvae of wood-boring insects from their tunnels in tree limbs. It is believed that the aye-aye locates its prey by tapping the wood with its fingers and listening for the difference in resonance when the area tapped conceals a burrow beneath the surface. The chisel teeth then come into play, gnawing down to the burrow, after which the aye-aye reaches in with its specialized, thin finger.

One of the factors contributing to the tenuous status of the aye-aye is its low reproductive rate; like most primates the female gives birth to a single young.

It was estimated in 1965 that the world's aye-aye population totaled no more than a dozen to 20 individuals. The estimate was probably too low, when one considers that the aye-aye is a secretive, nocturnal creature, but the status of this strange species is without question very grave. A population of aye-ayes was discovered in 1967 on the northwestern coast of Madagascar, but the future of the species is dim, unless an experimental transplanting of nine animals made in the same year results in establishment of a new breeding colony on an island off Madagascar. On that island, Nossi-Mangabe, French zoologists liberated a small group of aye-ayes in what they calculated was an appropriate forest habitat, free from human interference.

Whether the aye-aye will successfully colonize Nossi-Mangabe is a matter that only time will tell, but the future of the species may well depend on the outcome. Its survival on Madagascar itself seems doomed to failure in the face of today's odd combination of civilization and superstition.

JOSEPH A. DAVIS, JR.
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New York Zoological Park

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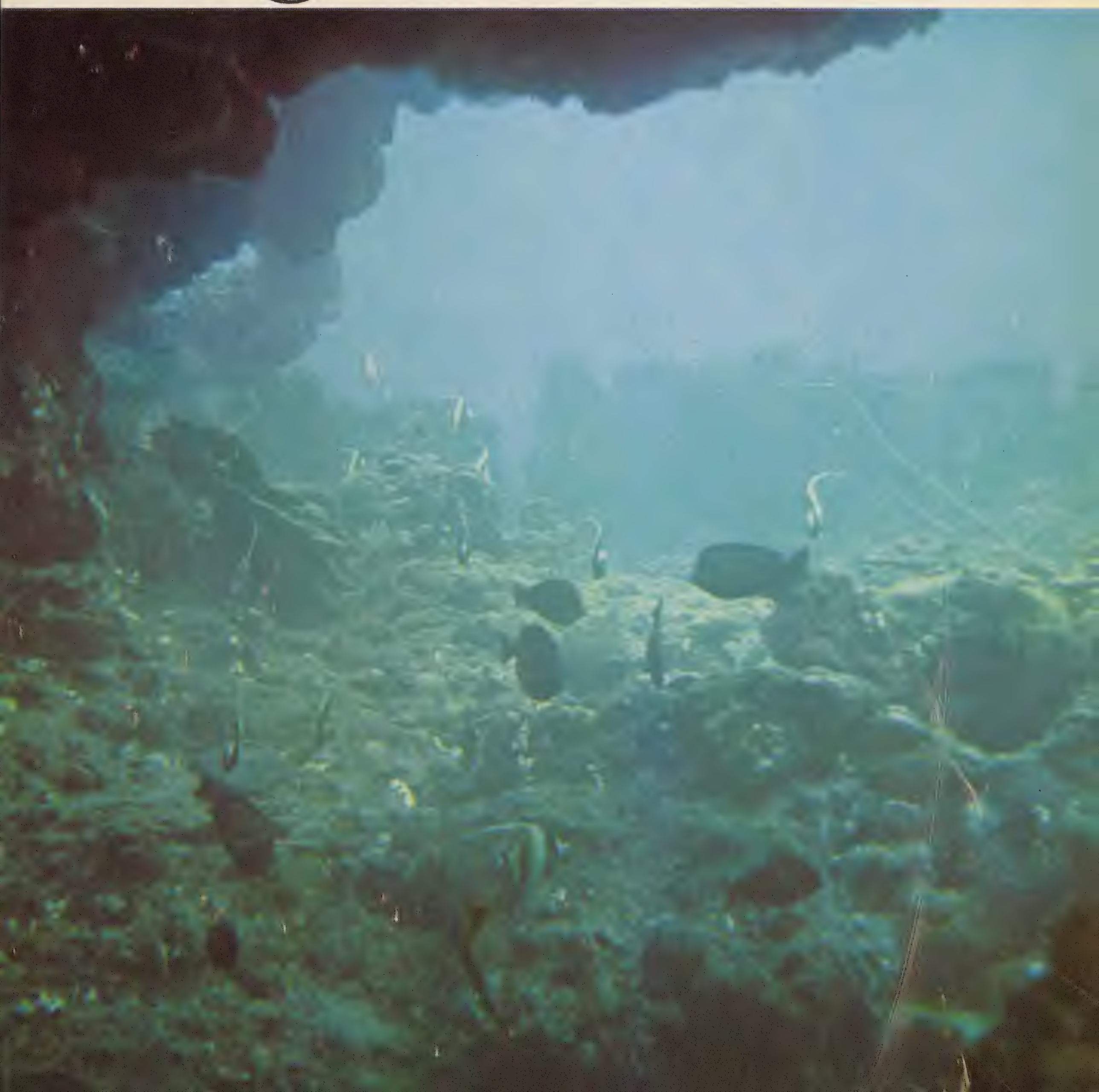
animal kingdom



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ABOUT THE COVER

Front: Fish near a reef off the coast of East Africa. Dr. Carleton Ray, one of the better-known marine scientists in the United, States, tells in this issue of the marine life of the East African nation of Tanzania. He examines the ecology of the meeting place of land and sea — and also provides us with a short course in the Swahili language. (See page 2.)

Back: Leopard *(Panthera pardus)* photographed in Serengeti National Park, Tanzania.

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MARINE PARKS FOR TANZANIA

BY CARLETON RAY

The author last year conducted a study of possible sites for underwater parks off Tanzania. "Marine Parks for Tanzania" is the title of a report resulting from the study and published in 1968 by the Conservation Foundation, 1250 Connecticut Ave., Washington, D. C. 20036. (Price $2.00) The study was supported by the Conservation Foundation, the New York Zoological Society, and the African Wildlife Leadership Foundation. – Ed.

Tall palms, more laden with the nests of chattering, arobatic weaver finches than with their own fruit, swayed gently in the wind. Beneath them, a cluster of adobe-plastered, thatch-roofed huts composed the fishing village of Mjimwema. Beyond the hot, white beach, the celadon sea rose and fell in long, calm rollers. Two fishermen high on the beach fired their ingeniously simple double outrigger with burning fronds to rid it of boring organisms. "Jambo," they said, smiling in unison.

Three months before, I had received a call from John S. Owen, Director of the Tanzania National Parks. Would I be willing briefly to lead a survey of some areas of coast to recommend whether they might be suitable as marine parks – to join with the famed Serengeti, Ruaha, Ngorongoro, and others. This summons was not to be ignored. With the joint support of the Trustees of Tanzania National Parks, the Conservation Foundation, the African Wildlife Leadership Foundation, and the New York Zoological Society, a new park project was born.

In early March, New York Zoological Society Trustee Peter R. Gimbel and I completed the flight from Paris to Tanzania's capital of Dar es Salaam to be met at the airport by Senior Park Warden John Savidge. He and his wife, Yvonne, were to be our hosts for the next two weeks. John and Yvonne live one of those idyllic but lonely lives in the midst of natural splendor. Their home and

A SHORT COURSE IN SWAHILI

asante = thanks (polite refusal)
asante sana = thank you (very much)
dudu = bug of any kind
fundi = expert
fungu = shoal, sand bank
jambo = hello
kitu = thing (plural: vitu)
kwa heri = farewell until the next time
mwamba = reef
wazungu = caucasians of western culture

headquarters is Ruaha National Park, 5000 square miles of unpeopled wilderness. John is a slender, wavy-haired Englishman who, like all Tanzanian park wardens, is both a skilled pilot and natural historian. Yvonne mothered us all with fine food and pyrethrum coils to ward off the "dudus" of the evening. She also found time to nurse two baby leopard tortoises, brought all the way from Ruaha for the purpose. She was to have her first child that summer, but bore the seasonal heat of coastal Africa with pleasant equanimity, usually with a coquettish smile upon her pretty face. "Swim?" she asked after dinner by starlight, and we were off 50 yards to a beach littered here and there with storm-tossed seaweed and cuttlebone. But before immersing a toe into the gentle surf alive with the sparkle of bioluminescence, I stopped to announce: "This is an important day in my life. In a second, I will have swum in every ocean!" And I jumped in, immediately to be rewarded for this bit of braggadocio by the itching sting of some small hybroid.

Tanzania resulted from the union of Tanganyika and Zanzibar in 1964. Its mainland coast is about 400 statute miles long from Kenya in the north to Mozambique southward. The northern frontier lies only about five degrees, or 300 miles, south of the Equator. Swahili, the ancient "trade" tongue of East Africa, is spoken in a purer form along the coast than in the plateau country to the west. It is a mellifluous language, somewhat reminiscent of Italian with a similar emphasis on the vowels.

A glance at topographic maps and charts reveals sharp zonation by land and sea. A green belt of coastal thicket, hot and dense, gives way to high open plateau and savannah westward and to a narrow continental shelf seaward. The hundred fathom line, bordering the continental shelf, that richest of the sea's provinces, lies from two to three miles offshore to a maximum of 50 miles where it includes the islands of Zanzibar and Mafia. (By contrast, the North Atlantic shelf is hundreds of miles wide.)

On the shallow shelf, coral reefs grow, exposed to fluviatile outwash of silt and to the pressures of nearby and increasing human population which lacks the means efficiently to exploit the sea. Because the shelf is so narrow, the interplay between clear, oxygen-rich, and nutrient-laden salt water necessary to reef growth and the silty freshwater run-off from the land is in especially delicate balance. Upon this natural balance man impinges with ancient hunter-gatherer methods, resulting in destruction of habitat, pollution, and overfishing.

The pattern of population pressures producing environmental destruction at an exponential rate is world-wide. But where the resource is so narrowly delimited, it is particularly severe. Lately, tourism, a source of dollars vital to the African economy, and resultant recreational development have entered the picture. The problem of safeguarding productivity and esthetic values in the face of these pressures, aggravated by general biological ignorance of the sea, is a massive task in which marine parks and reserves have a vital role. These are not parks and reserves in the terrestrial sense, for unlike the land, the sea cannot be fenced and sectionalized. Water does not recognize fences. The living continuum of the sea is a three-dimensional, poorly-understood whole, and man's reckless exploitation of it is rendering it just as depauperate as the land.

The first day of our stay, we met Fisheries Officer Iain J. B. Robertson, a dark, thin, tall "fundi" on molluscs and without a doubt the best-qualified local person to advise on Tanzanian coastal resources. He had been instrumental in the drawing of a modernized fisheries plan for Tanzania and had identified areas of special interest as potential parks and reserves prior to our visit. We

though it best to begin with an aerial reconnaissance. We packed our "vitu" and soon took off in John's Cessna 180 for a flight from Dar es Salaam harbor eastward across the narrow shelf toward the oceanic island of Latham, thence south to Mafia Island. As we flew over Dar es Salaam, justification for its name, "peaceful harbor," became obvious. The city is located on a tranquil embayment, utterly protected from the monsoons. Its muddy port water turned to the familiar green of the shallow tropical sea outside the narrow harbor entrance, white bottom alternating with the blackish of turtle grass and browns of other growth. We flew along the south side of the bay outside the harbor towards Mjimwema, where the white of our beach was interrupted by a little delta spewing lovely patterns of silt into the sea. Just offshore, Sinda Island appeared, its seaward coral reefs rising in ridges and undulations of browns and greens and yellows. This most accessible reef from Dar es Salaam is a prime area for park development and protection, but it is under heavy pressure from local people who net fishes and gather molluscs and other produce of the sea from its flats and reef.

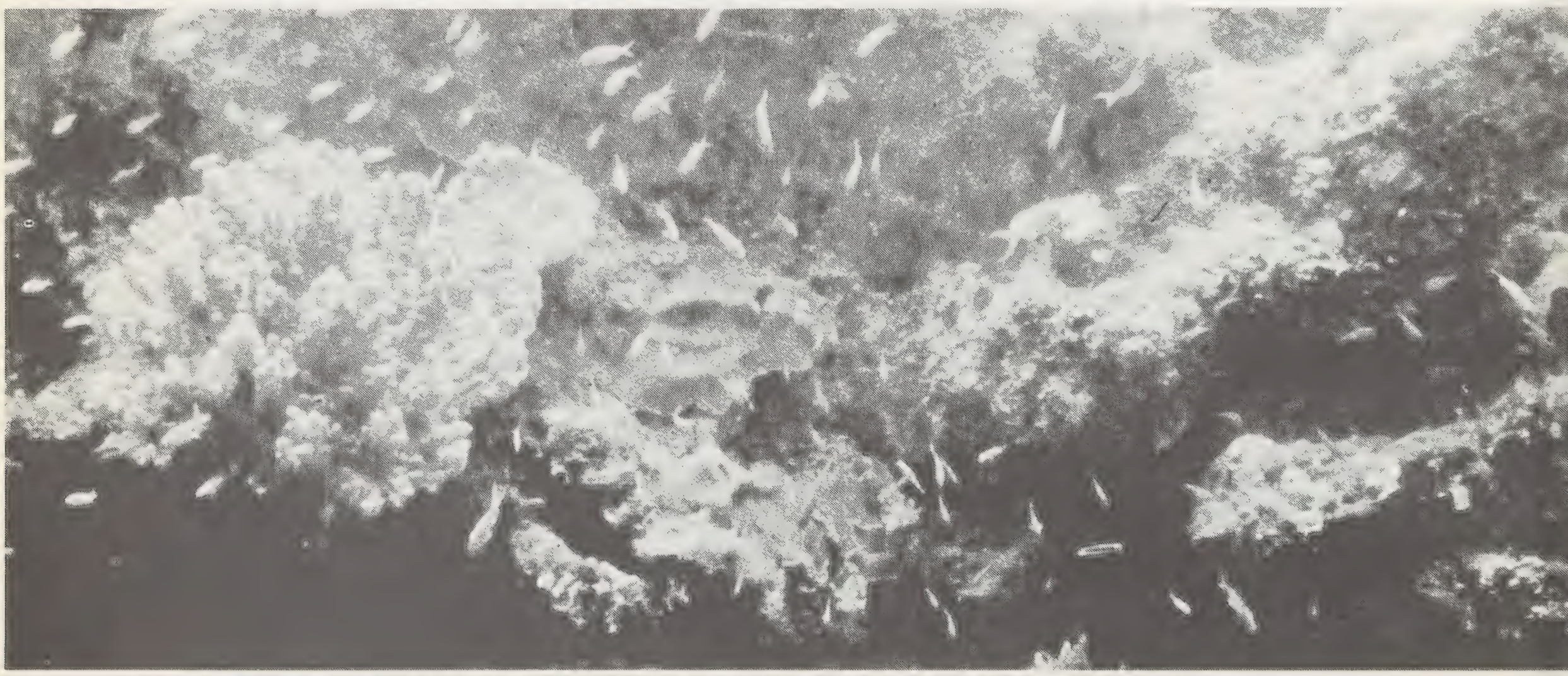
Just beyond Sinda, the water turned sharply blue at the 100-fathom line and we were over the Indian Ocean. Latham Island lies about 45 miles almost due east of Dar es Salaam. It is a tiny, low-lying island, and by virtue of its isolation, great colonies of ground-nesting sea birds seasonally inhabit its dry elevated area. On its beaches green sea turtles nest, but these are evidently much reduced from former times.

Turning southward, we flew another 50 miles for Mafia, an island of about 30 by 10 miles, its long axis in a northeast-southwest direction. Mafia presently has a rural and fishing population of 12,000. Offshore, the southeast-facing reef is at the very edge of sea where the bottom drops rapidly away. From its northeast tip to Chole Bay, 20 miles south, this offshore side is protected by a fringing reef which encloses a slender lagoon.

A cliff, with blowholes spurting water as the rollers break, forms an inhospitable face of the land. The reef itself rises to within six feet or less of the surface and is bisected at right angles by a series of regularly-spaced surge channels so that the reef alternates in dark green and white. Outward, the bottom slopes down rapidly without sharp features. Clearly, the buffeting of waves on this exposed side has planed the reef, not allowing delicate branching corals to grow high, as in quieter waters. This is obvious from April through September when the southeast monsoon blows and the north-running Poma Current increases from about a knot or two to five knots, making this offshore reef all but inaccessible. However, March is the end of the calmer northeast monsoon, and the surge-channels-to-deeper-water beckoned us to dive.

On Mafia's lee, or northwest, face a shallow bank is covered by clear blue-green sea water dotted with coral reefs and islands. About halfway to the mainland the coral disappears, and the water turns at first murky, then, at a line, brown with the effluent of the Rufiji River Delta. When either upland deforestation or rains are heavy and run-off increases, the muddy freshwater extends at times far out onto the shelf and kills of coral occur. The waters between the mainland and Mafia comprise an area called an "ecotone," the dividing line between two ecosystems – in this case the shallow coral sea and silt-laden delta water. Here, under pristine conditions, hippopotamus and crocodile would meet dugong and sea

A school of fry swims among the reef off Mafia Island, Tanzania, an outstanding area for park-reserve status.



turtle, and as is the case with most ecotones, life would be at its most varied and productive.

We flew to the delta itself, spread green and flat and interwoven by channels containing lazy brown water; thence southward and outward to the edge of the sea again, along the rich and relatively unmolested reefs of Tutia and Kibondo, the Juani Island with its old Arabian ruins of Kuwa, and to Kinasi Gap, the entrance to Chole Bay. In the bay a dozen huge manta rays swam gracefully, probably gathering to mate or to feed upon small schooling fishes that comprise the major portion of their diet. Their size attested to the appropriateness of their name, translated "blanket" from the Spanish.

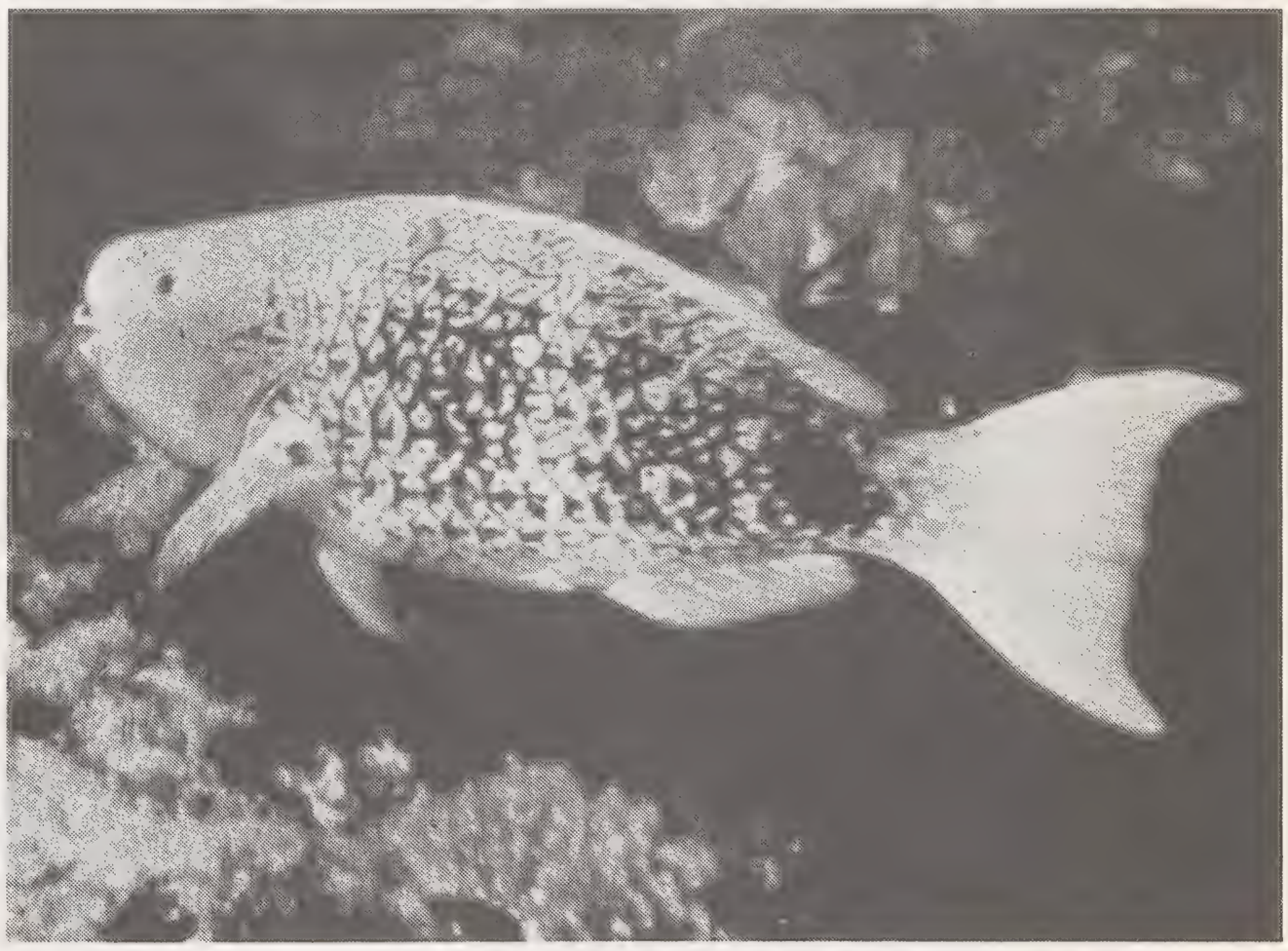
Hardly a better site for a park and reserve could be found anywhere. In a few moments, we were on the small grassy airstrip that services the fishing club on Chole Bay. We were soon advised that this club was only the first to be built. Development unhindered could only spell the destruction of much that we had seen. Spearfishermen in quest of huge fish had already begun their work, a recent group having taken many large fish, mostly to be left uneaten and wasted. Time was clearly short.

Our flight had established an overview of a cross-section of local sea. Now by diving we were to seek "ground truth." Peter Gimbel and I first dove among the surge channels north of Chole Bay to about 90 feet down the sharply sloping bottom. The channels were smooth-sided, covered with growth of algae and coral. Water was somewhat murky due to the proximity to surface turbulence. But beneath it and among the low ledges down the slope, the water became clearer. Purple and brown soft coral, which seem to luminesce, carpeted the bottom in a profusion of productivity. Massive anemones in which clownfishes took refuge were abundant.

Above low corals of brown and yellow swam large schools of gray unicornfish. A small shark snooped along the bottom and a pod of barracuda hung in mid-water. Occasional pods, or schools, of large jacks hove into view, each fish with the permanent scowl nature has provided, while more numerous rainbow runners made off up the reef. As if cognizant of its clownlike appearance, the triggerfish, *Balistes conspicillum,* swam slowly, its toothy mouth, fins, and belly marked in huge white circles that possibly advertise toxic or noxious flesh.

In the midst of this profusion we swam, knowing this place with its exposure to the open sea, occasional sharks, plentiful barracuda, and strong currents would not be hospitable for most snorkelers, but also knowing that for the more adventurous such a place would avidly be sought out. The chance would be good that here, in a cave or under a ledge, one might meet (as we did later farther north) the largest of all basses, the giant Indo-Pacific jewfish. This fish grows to over 10 feet or even 12 feet in length and a weight of no doubt a ton. It has been reputed to gobble up native divers, though normally basses are timid or at least aloof in the face of man.

The jewfish is a homing variety, slow-growing fish, and a prime target of the spearfisherman who usually has no conceivable way to utilize the mounds of meat. Along the United States coasts a related jewfish inhabits reefs, ledges, and offshore oil rigs and has been subject to over-predation by zealous spearfishermen, who once posing with their kill often consider their duty done. It is partly for the protection of some of these spectacular beasts that the concept of marine parks and reserves has been developed.



The parrotfish takes its food from coral, biting out chunks of reef and often leaving distinct tooth marks.

There is discussion among marine biologists about the reasons that reef fishes are so spectacularly colored. It is known that many animals, notably the zebra, have evolved a bold disruptive pattern to camoflage the pattern of their outline when they are immobile. Rarely, however, are the brightly-colored reef fishes still. Some reef fishes have ocellated "eye" spots near their tails, and it is supposed that these are confusing to the predator who, striking at a supposed front end, is rewarded by a mouthful of water as the fish escapes "backward."

Further, it is supposed that some bright colors serve to advertise distastefulness or toxicity as is perhaps the case with *Balistes.* However, it would be foolish to seek a single answer to such a question as "Why are reef fishes so brightly colored?" All these explanations, a dozen more, or none may be true depending on the species in question. The truth is that while many explanations are put forward, very little field or experi-

Many beautiful, colorful fishes inhabit the tropical waters off East Africa, among them the Moorish idols, with their long dorsal filaments (above) and the angelfish (at right).

mental data are at hand to substantiate any of them.

Let us take the question from the standpoint of the diver. My own major field of endeavor happens to be the polar sea, most particularly the seals within it. In Arctic waters, the fishes – mostly of dull coloration – are few in species though great in numbers. This is due to the fact that there are few niches or "ways of life" available in the wide expanses of "sameness" of environment.

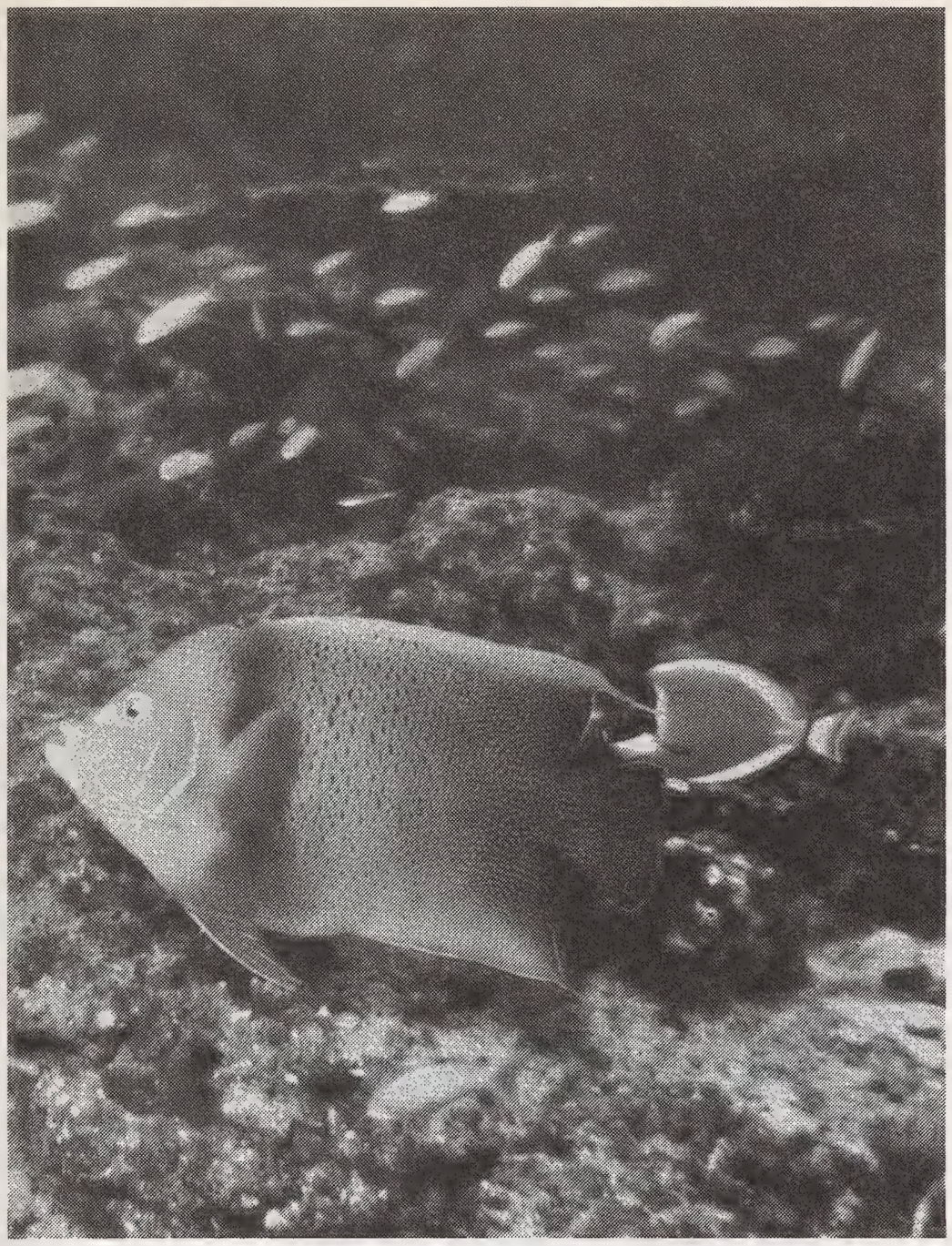
In tropical waters, by contrast, the number of species is very great as the niches are numerous. The total mass of life may be roughly the same as in polar waters, but the biomass is split between literally thousands of species. The diver in this tropical variety is able easily to identify those bright species which swim about him. Angelfishes flag yellows as they open and close their pectoral fins. Moorish idols, striped in yellow and black and trailing long dorsal filaments, often swim in pods with similarly-marked coachmen. A spot on the side reveals a snapper of one species; one on the tail, a grunt. Could not these colors and patterns serve fishes as signaling devices? Fishes have color vision. Some recent studies indicate that the unique colors and patterns seen on the reef serve fishes most in social ways. As the heady world of color and motion on the reef is esthetically pleasing to us, it is also an ideal for the ethologist who is seeking the possible significance of all this brillance. Perhaps it lies in social signaling.

Yet some reef fishes are hidden from our view, seldom emerging from holes and burrows. Others, such as the deadly stonefish, which leads a sluggish life and is almost indistinguishable from the rocks in which it lies, ambush smaller fishes. In the water above, predators such as the barracuda and some sharks are countershaded so as to appear self-colored with the water. All is not brillance on the reef.

Nor does the reef bear a single face. Dive the reef at night and the species seen by day may be there no longer: parrotfishes, triggerfishes, wrasses, and others sleep in a bed of mucous secretion or in crevices or in the sand, or they disperse out over the neighboring bottom to feed. The day population is replaced by a nocturnal complement of red squirrelfishes and others which spend their days in comparative seclusion. At least, the reef is a tumultuous, constantly changing place, the ultimate in diversity and biological interaction on this Earth.

Later we dove in Kinasi Gap. This entrance to Chole Bay provides the principal inlet and outlet for the 10-to-12-foot spring tides that flush the bay twice daily. One can dive such places only an hour either side of high or low water when currents are not strong. We anchored in shallow water just to the side of the gap and in we went. We swam over a carpet of swaying turtle grass, rich and green. As we passed around a huge mass of *Acropora* coral with its complement of sergeant majors, we peered down into the blue-green depth of the gap.

As is usual with such places where currents fluctuate strongly between bay and sea, nutrient and oxygen levels are high, the coral extremely luxurious, and the fishes abundant and varied. Stacks of coral were inundated by schools of little wrasses. Every nook contained its demoiselle, and anemones harbored both clownfishes and schooling demoiselles, called *Dascyllus*. In the gap itself, larger fishes swam strongly into the current just to stay in the same place. We rounded a large coral head and the current could not be avoided. It carried us out and along the reef toward the bay. In gentle weightlessness, we were carried down to a depth of 50 feet past coral and schools of fish. Suddenly, the end of the reef was in view, and we ducked back around another head to calmer water



and toward the boat.

If one could but plan the ride, this tidal conveyor would carry the diver past a stunning panorama. Nevertheless, these same currents can be frightening and enthusiasm should be damped for riding them. Some dip down to take the diver well beyond his depth. Often they carry the diver farther from his boat than he should safely go, and man and boat lose contact.

Mafia – with its ecotone to the Rufiji, its offshore reef with the blue sea beyond, and its inshore protected reef, Kinasi Gap, Chole Bay, and the ruins of Juani – offers undoubtedly an outstanding area for park-reserve status. It is as ideal an area for marine conservation practice as is known to me. The area is large and complex and bears a relatively small human population, which could be led to excellent management of the marine resource. It contains habitat for the existing remnant populations of at least two endangered forms – green sea turtle and dugong. It contains examples of every kind of coastal Indian Ocean reef, some of them as yet untouched. Drainage from the Rufiji is not severely changed by man. This is a natural place that the Tanzanians – and the world – deserve in perpetuity.

Though Mafia occupied us most during our brief stay, we were also to examine other areas which had been commended to us by Iain Robertson. Together they could be developed into a park-reserve system without equal in the world today: Tanga's Mwamba Shundo, Mwamba Wamba, and Fungu Nyama coral gardens; Maziwi Island's green turtle nesting beaches; Mbudya and Sinda reefs near Dar es Salaam; Latham Island's breeding areas for oceanic birds and green turtle; Kilwa, site of the best remaining dugong population in Tanzania. Tanzania is a relatively small and poor country but its taxpayers spend three times as much (on a percentage of income basis) for its parks than do the citizens of the United States, where the national park concept was born. Tanzania National Parks has grown from one park in 1961 to six today with four more on the books. Thus, while Tanzania is not so developed by the usual economic and perhaps erroneous standards which mark "wazungu" progress, marine parks could be established there with relatively little of the conflict of interests which marks our own efforts. The United States has only three major marine parks: one in Florida, one in the Virgin Islands, and one in the Dry Tortugas. National Seashores extend their jurisdiction only to the high water mark and are not marine parks. This is precious little for such a nation, and marine conservation is not progressing here as it should.

Tanzania is not a country with a modern fishery. The native population must depend upon taking what is near at hand by methods which yield low returns with large effort. Hunter-gathering on the reefs has depleted many species and has resulted in habitat destruction. Dynamiting, though illegal, is still practiced due to lack of policing. Seining with fine mesh nets handled by 20-man (or more) teams is hugely destructive; it catches fish, large and small, of many species and results in trampling of the reef where it is practiced.

The coral reef and its faunal populations have great recuperative powers, but in the face of these practices and with the addition of dredging, siltation, pollution, and mineral exploitation, many reefs may be totally destroyed in a short time. Unfortunately, these are mostly the same reefs the tourist will likely want to visit. Thus, parks must be planned together with fisheries and tourism on a cooperative, noncompetitive basis. Above all, research is needed prior to and concurrently with planning and development.

Tanzania's marine resources are rich. But parks cannot be planned as enclaves in an otherwise depleted sea. Seriously impeding parks planning is the fact that most of the sea is a *res nullius* where no man or nation can singly determine any course of events. Perhaps through the sea man may learn finally that this is indeed one world, that inner space is more suitable and important for our attention than outer space. In any case, after the sea, what? It is my fervent wish that Tanzania and other nations of East Africa will succeed in the role of marine conservation and will show the way to a marine parks system without peer. Then we can say "asante sana" and "kwa heri."

SCORPIONS by Donald F. Bruning

As I walked in the door, I caught a glimpse of movement on the living room floor. A small brownish-red object was traveling across the gray carpet, heading for the bookcase. Immediately, I knew that it was a scorpion, and a venomous one at that. I stepped past the animal into my bedroom and grabbed a long pair of forceps and an empty jar from my desk. Back in the living room, I carefully picked up the scorpion with the forceps and placed it in the jar as it squirmed violently to escape. Looking more carefully at the scorpion now safely in the jar, I confirmed my first impression that this was a *Centruroides,* the genus that contains the most venomous species in North America.

Quickly I looked around the room to see if any more scorpions were about. Then I went into the bedroom and carefully checked each of the aquariums that I had on the floor and table to be sure that no other scorpion had escaped. After counting all of my scorpions, I breathed a sigh of relief and started contemplating how to prevent a reoccurrence.

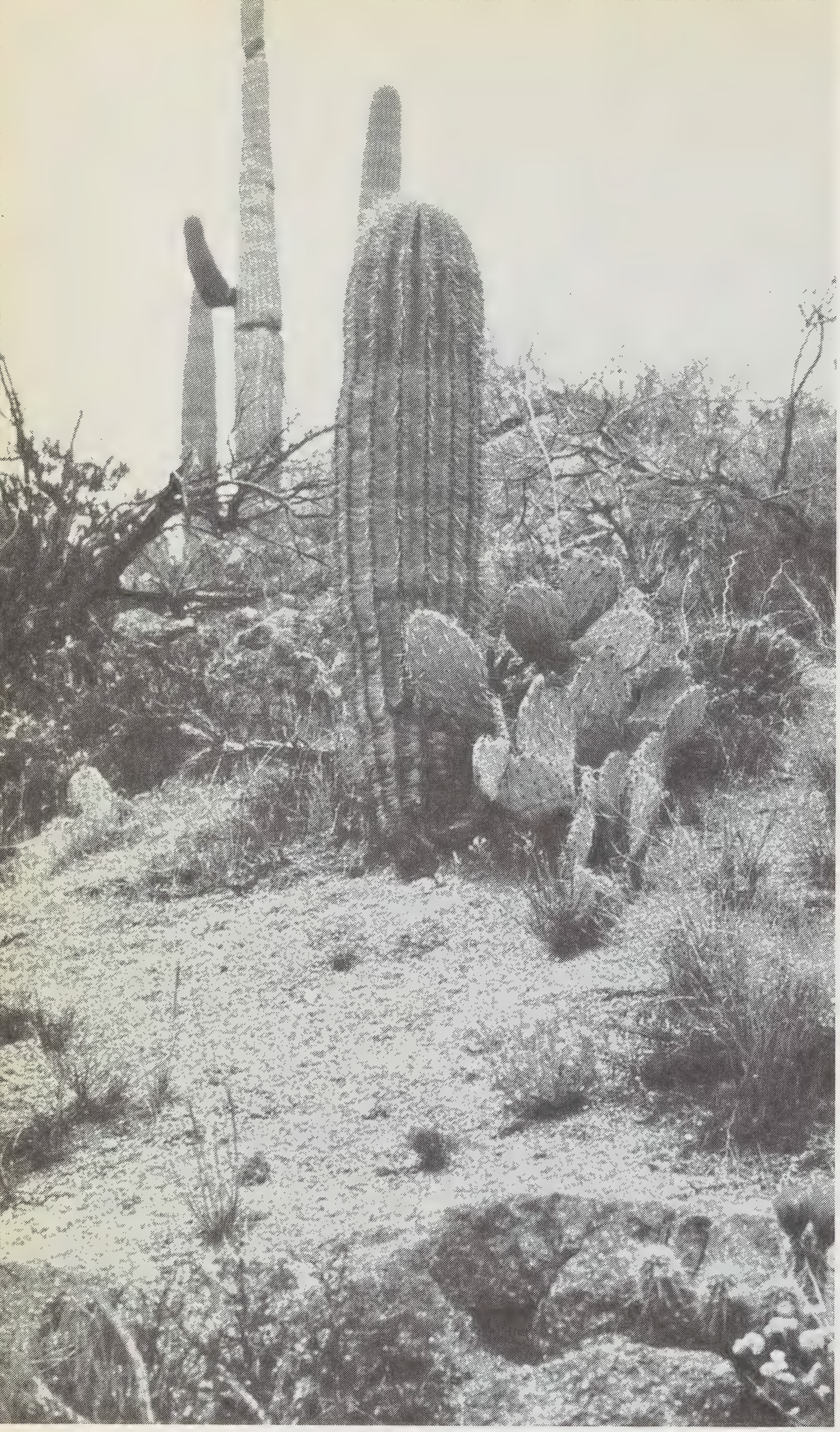
My interest in scorpions had really started in the spring of 1966 while, as a graduate student at the University of Colorado, I participated in a reptile collecting trip to Arizona and New Mexico. The aim of our group of graduate students was to collect several species of lizards for our own research as well as to acquire specimens for the university's museum and for other research workers.

While rolling over stones and stumps in search of reptiles, we often uncovered scorpions. One member of our group, Wes Brown, had an interest in scorpions and wanted to collect some of these arachnids. He showed me how to handle them and how to distinguish the three species found in that part of Arizona. Early one morning we set out to collect some scorpions, and it soon became a game to see who could find the most, and who could find the largest and the smallest specimens. We found that turning over rocks, logs, and dead cacti became quite enjoyable, because we never knew just what we would discover underneath them. The only tools that we needed were a three-pronged rake for turning over rocks and stumps, long forceps to pick up the scorpions, and a jar to hold the specimens.

At night while sitting around the campfire, we discussed scorpions and how little is really known about them. Scorpions have the reputation of being very deadly, but very few are more toxic than a bee. This reputation has been built up by their use as deadly weapons in novels and movies of intrigue. Scorpions have always been associated with evil in stories and legends. As we talked I became more and more fascinated, and by the following day I started collecting scorpions for a research project of my own.

By the time we reached Tempe, Arizona, a few days later, I had not managed to collect nearly as many scorpions as I had intended. We stopped at Arizona State University to visit a friend, Dr. Neil Hadley, who introduced us to Dr. Stan Williams. Both Dr. Hadley and Dr. Williams had been studying scorpions and they took us outside Tempe to an area where they collected these arachnids for their studies. Here we found that empty coffee cans had been placed in holes in the ground, so that they served as open trap pits. These were partially covered on top with rocks or stumps. Dr. Williams had traplines of over 500 coffee cans that he checked every few days to remove the scorpions and other animals that had fallen into the traps.

Until quite recently, when researchers such as Dr. Williams and Dr. Hadley started studying scorpions, very little was known about scorpion behavior or natural history. However, the venoms of the more dangerous species have been studied extensively, as have the venoms of our most poisonous snakes, so that antivenins could be developed.



The Sonoran desert of Arizona with its sand and cacti provides a typical habitat for scorpions although they are not strictly desert creatures but occur in all types of habitats, from desert to tropical rain forests.

Scorpions belong to the class Arachnida, which includes the spiders, ticks, mites, and the harvestmen. Fossil relatives date back to the Silurian Period, more than 350 million years ago. Scorpions are in fact the oldest known terrestrial arthropods and may have been the first members of the entire phylum to conquer the land. The Eurypterids, or sea scorpions, were probably the ancestors of the first terrestrial scorpions. The Eurypterids date back nearly 400 million years and include what is thought to be the largest arthropod of all time, an animal which may have reached nine feet in length.

All modern-day scorpions are terrestrial and inhabit tropical and subtropical areas. They are not strictly desert creatures as many people believe, and they are common in all types of habitats, from deserts to tropical rain forests. Some species live in burrows while others live under rocks, in crevices, in logs, and even in trash piles.

Scorpions feed mainly on insects and other small invertebrates, but they will eat any small animal that falls into their grasp, including small lizards and even small mice, if they can hold their prey long enough to sting it.

All arachnids, including scorpions, have four pairs of legs and one pair of pedipalps, appendages quite similar in appearance to the claws of a crab or lobster, which are used for gripping. The segmented thorax of the scorpion slowly grades into the abdomen, which is tipped by the stinger. The pedipalps hold the prey while the stinger injects the venom. The venom, produced by a pair of oval glands near the posterior end of the abdomen, is forced out through the stinger by muscular contractions. The stinger itself is hollow and works much like a hypodermic needle.

The great majority of scorpions can deliver a painful, but not fatal, sting. The most toxic venom is produced by the North African genus, *Androctonus,* and the North American genus, *Centruroides.* The vast majority of North American species have a sting approximately equivalent to the sting of a hornet or yellowjacket, and those of some species have almost no noticeable effect. At the same time, the venom of one African species, *Androctonus australis,* is said to equal cobra venom in potency; it can kill a dog in seven minutes or a man in six or seven hours. Some of the species of *Centruroides* found in Mexico and the southwestern United States have caused many deaths, most victims being children.

Children are the most common victims of scorpion stings because of their curiosity and because they are more likely, playing outdoors, to come into contact with a scorpion than the average adult. Education of the public and the development and accessibility of antivenins in recent years have greatly reduced the number of deaths from scorpion stings.

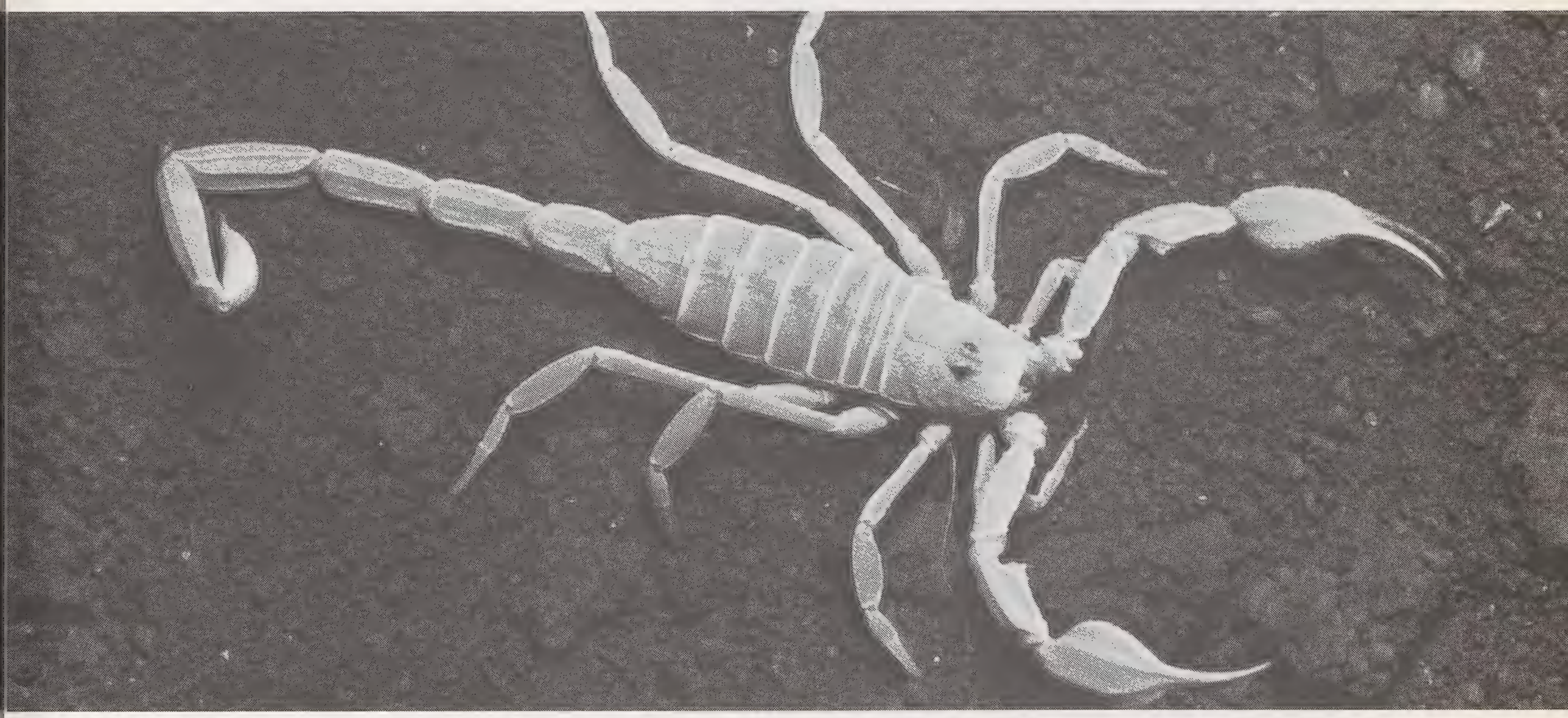
The venom of the more deadly species of *Androctonus* and *Centruroides* is generally neurotoxic and can cause convulsions, paralysis of the

respiratory muscles, and cardiac failure. Antivenins have been developed for all of the dangerous species, and they are completely effective if administered within a short period of time after the sting. However, it must be remembered that the vast majority of scorpions are not deadly and do not deserve their terrifying reputation.

Scorpions are very hardy animals, but I did not realize just how hardy until I had studied them in the laboratory for some time. They are able to prevent any substantial water loss even when exposed to very low humidities for long periods of time. I found, weighing each scorpion twice a day, that these animals can not only prevent all but a minimal water loss when kept in an enclosure at zero percent humidity, but they also can survive under these conditions without food for at least 60 days. After that length of time I felt that I had definitely confirmed the fact that scorpions are very good at conserving water; this ability is probably one of the major reasons that scorpions have been so successful and have survived until the present time, changing very little from their ancient ancestors.

One day while weighing my scorpions, I was busy talking to a friend, who was working in the same laboratory. I had just opened one scorpion jar when my friend asked a question, and I turned away from the counter for a moment to answer him. When I returned my attention to the scorpion, I suddenly realized that not only was it out of the jar, but it was crawling up my arm. With one quick shake, the scorpion was back on the bench, but I continued to shake for some time after that close call.

In June of 1967 I accompanied Dr. Hadley to Cholla Bay on the eastern side of the Gulf of California to assist him in a study of the activity of the scorpions in that part of Mexico. It is quite easy to observe scorpions at night with the help of ultraviolet light, as the exoskeleton of a scorpion glows under "black light." (Ultraviolet light is that portion of the sun's natural spectrum which is just below visible light, and it is probably most familiar to us from the sunburn that it causes.) Scorpions do not seem to be sensitive to ultraviolet light, as they continue with what seems to be normal activity and show no sign of detecting the light.

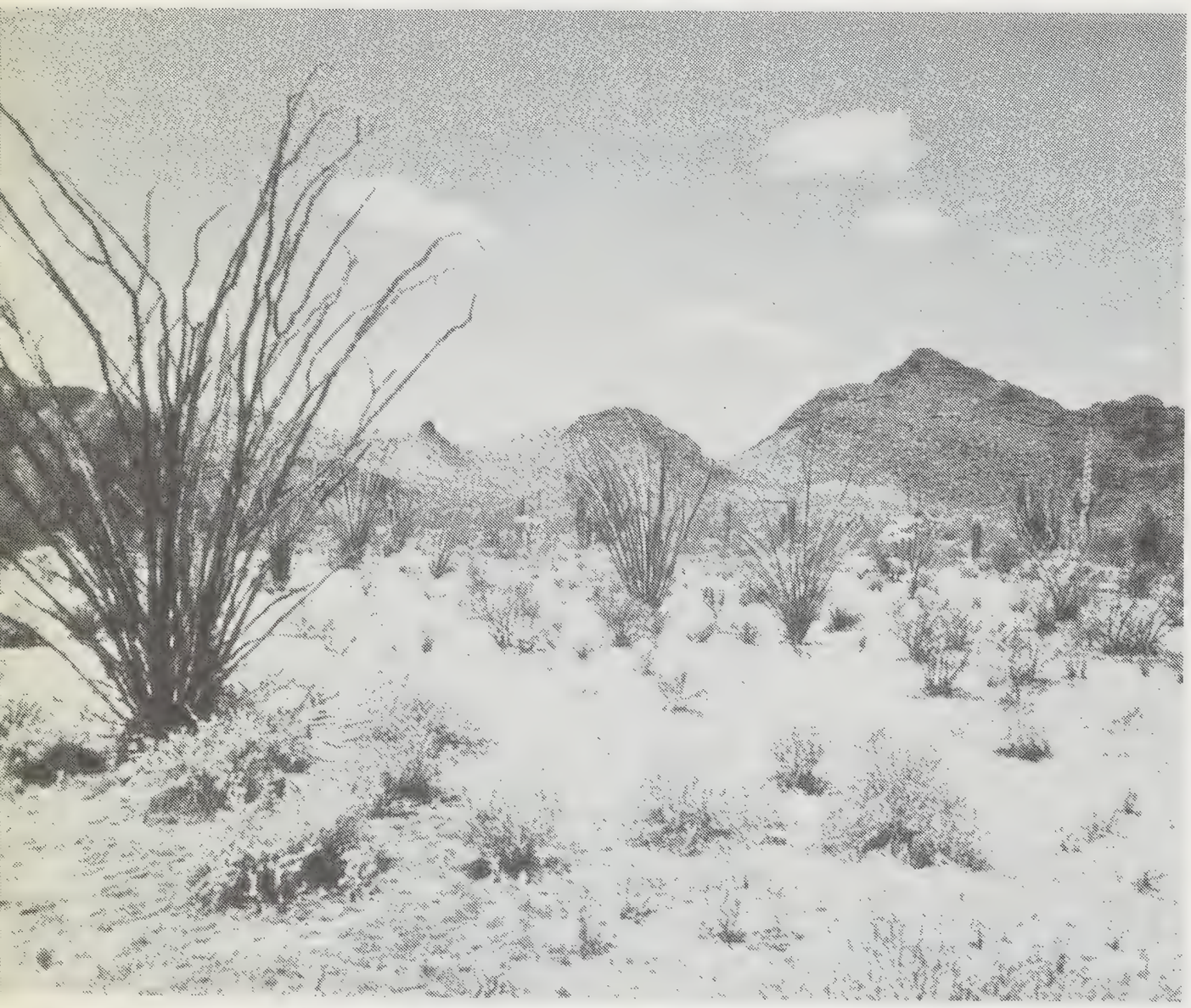


The exoskeleton of a scorpion shimmers under ultraviolet light, enabling researchers to study scorpion activity at night.

One day, by accident, I discovered how tolerant these animals really are. I was about to weigh a scorpion when I dropped it into a pan of concentrated sulfuric acid. The animal immediately stiffened up, apparently dead. Not taking any chances, however, I carefully washed the scorpion in a pan of water and replaced the creature back in its jar. The following morning, to my surprise, it was perfectly healthy and very active.

I somehow managed to weigh as many as 30 scorpions twice each day for over four months without being stung, but not without near-misses. However, they react to normal white light by immediately scurrying for their burrows or the shelter of the nearest rock.

Watching scorpions at night is an adventure, but it can also be quite a harrowing experience, considering that one is walking through huge beds of cactus and rock – great rattlesnake country – with only the dull blue glow of an ultraviolet light to show the way. The surprising and beautiful pastel green glow of a scorpion's exoskeleton makes up for any uneasy moments; it can often be seen for 10 feet or more on a dark night.



Members of the genera *Hadrurus* are burrowers, inhabiting such sandy desert areas as shown above. The *Hadrurus* shown at top measures about three inches in body length.

As Dr. Hadley put on his knee-high "snake-proof" boots I couldn't help wondering if he was not unduly worried about snakes. After just a few minutes in the field, however, I discovered the real reason for the knee-high boots; they were protection from the terrible cholla cactus rather than from snakebite. After experiencing great pain the first night and spending the following morning pulling cactus spines out of my legs and feet, I developed my own "snakeproof" or "cactus-proof" boots. I rolled newspapers around my legs under my trousers, and this seemed to do the job. The newspapers were a little awkward and did not fit into the tops of my boots very well, but they protected my legs from the cactus spines.

Dr. Hadley and I located and marked over 100 scorpions within the first three nights. The animals were given one small spot of fluorescent paint by touching them with the tip of a small brush that had been dipped in paint. A marker of the same color was placed beside the animal so that we could locate the spot the following day. By the following night the marked animals were behaving just as they had before they were marked, but now we could identify each animal and the location in which it had been observed when it was marked.

For the next five days we tried to keep track of where each scorpion was each day, to determine the size of its own "territory." Surprisingly all the species of scorpions that we studied, with the exception of the *Centruroides,* moved very little from hour to hour or even from day to day. They all seemed to remain within a few feet of their burrows. Even the *Centruroides,* which move about actively foraging at night, were seldom seen more than five feet from the spot at which they were marked.

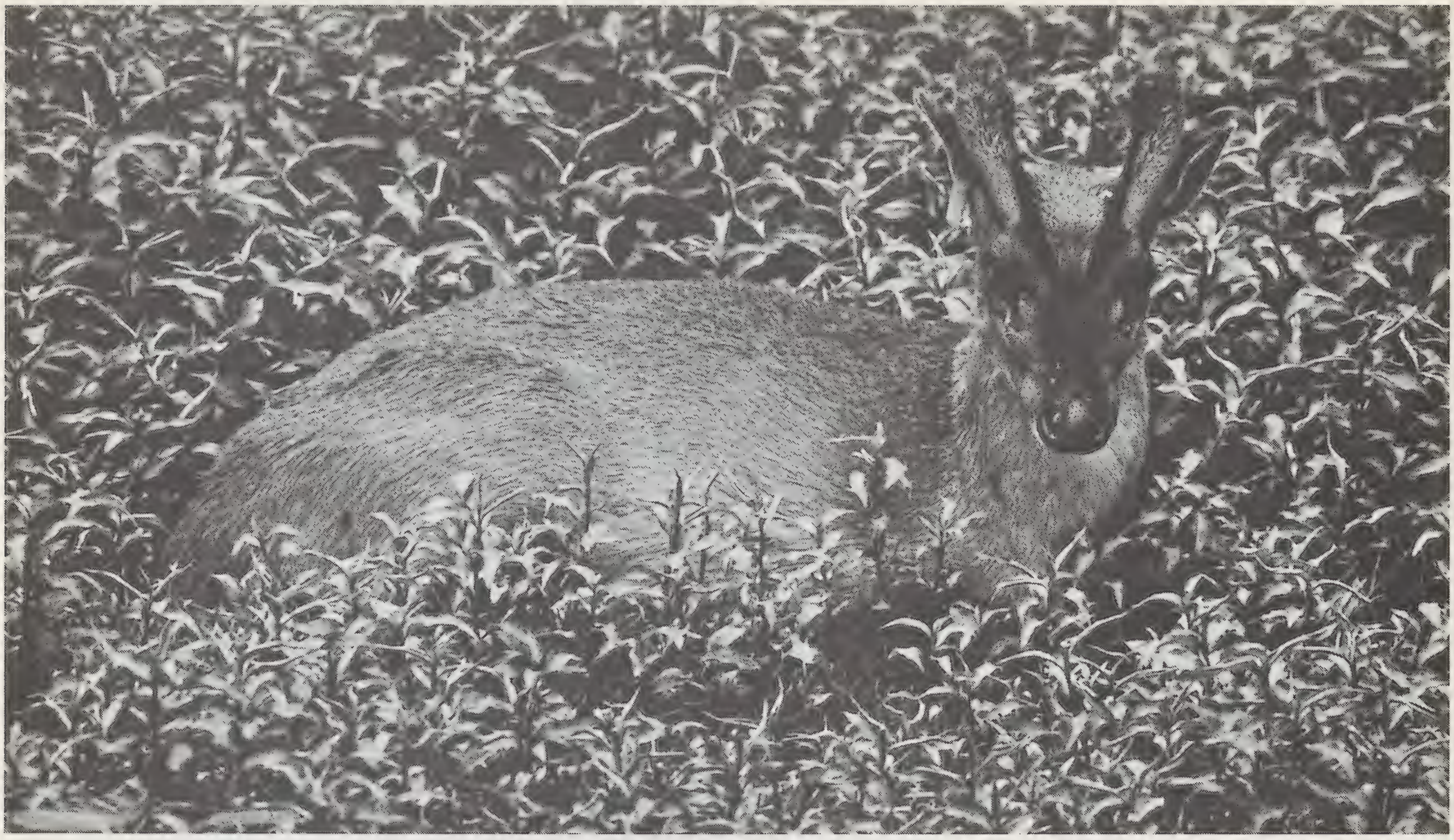
All too soon I had to return to Colorado, but I went back with a car full of scorpions. I found that these animals can be quite easily transported in plastic bags which take up a minimum of space. The only severe problem is that scorpions become cannibalistic if they are kept in close quarters for any length of time. To keep scorpions for longer periods, it is necessary to place them in a terrarium with sand, soil, or some other suitable substrate which is as similar as possible to their natural habitat.

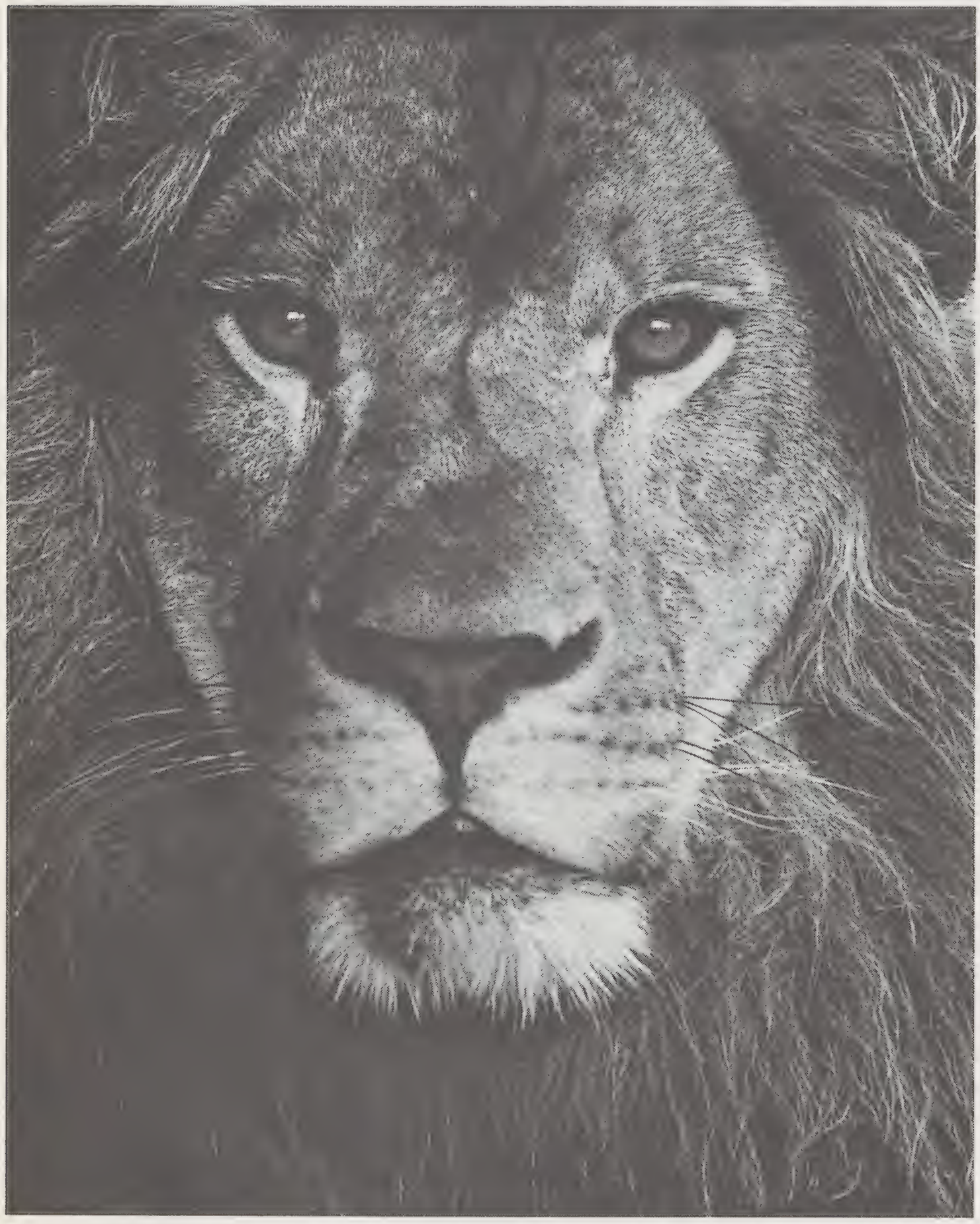
Scorpions, when active, are quite fascinating to watch. The members of the two genera *Hadrurus* and *Vejovis,* are mainly burrowers and spend most of their time in their burrows or digging new ones. The poisonous *Centruroides sculpturatus* are very active feeders; they come out at night and search cracks, crevices, bushes, logs, and rocks for any insect, spider, or other small creature that they can eat. They move slowly and deliberately with their pedipalps checking out every corner where a potential meal might be hiding. Often they can be seen several feet above the ground crawling through the bushes or trees. (It is probably because of its active nature that the poisonous *Centruroides* escaped from its aquarium in my bedroom. As a result of that escape I had to place a top on all of my aquariums that contained *Centruroides.*)

Scorpions are undeserving of their bad reputation since only a few species are really dangerous, and as predators, they help to maintain the balance of nature wherever they are found.

AT THE ZOO

PHOTOGRAPHS BY
PAUL G. KOVAC





OVERLEAF: GRAY HERON
ABOVE: REEVES' MUNTJAC
AT LEFT: LION
FAR RIGHT: SIBERIAN TIGER

ABOVE: ORANG-UTAN
OPPOSITE: FORMOSAN SIKA

The family Boidae (boas and pythons) includes all of the largest and some of the smallest living snakes. Boidae native to the Americas are distributed from Canada to Argentina, from near sea level to elevations of nearly 9000 feet in the mountains. Boas inhabit arid deserts, scrub forests, rain forests, and even cloud forests. A similar situation prevails in the Old World where the pythons outnumber boas. Members of the family have gained access to six continents, a distinction they share with few other families of reptiles.

Offhand the family Boidae would appear to be an adaptable, flourishing assemblage of snakes. But is it? Paradoxical though it would seem in view of the wide distribution of the group, the boas and their relatives may well have begun their decline millions of years ago. A few species, most notably the boa constrictor of the Americas, are thriving, but others are not. Close examination of the ranges of boas and pythons reveals that they are thinly and unevenly distributed in the six continents inhabited by snakes. The fossil record, meager as it is, leaves no doubt that members of the family Boidae once occupied portions of the globe where boas no longer exist.

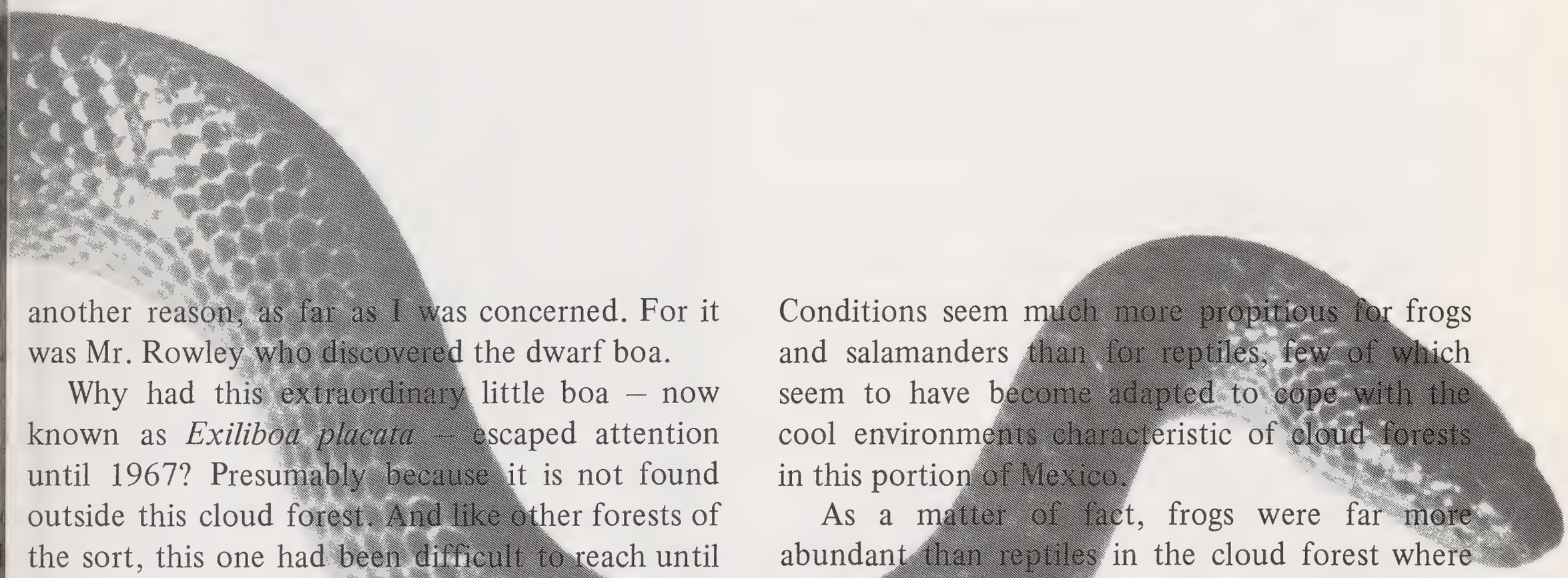
At the peak of their dispersal and diversification, the boas and pythons may well have been the dominant snakes on every major land mass inhabited by reptiles. They were perhaps the first snakes to exploit aquatic and arboreal as well as terrestrial habitats, and the first snakes to reach many of the islands. Possibly every part of the world suitable for snakes was once inhabited by the ancestors of boas, but today vast areas occupied by other snakes have no boas. We find boas with fragmented ranges, or boas restricted to small, isolated populations on islands or mountain tops.

It was the discovery in 1967 of a dwarf boa in a cloud forest in southern Mexico that led me to consider the plight of the Boidae. The snake was in a forest situated on the northern slopes of the Sierra de Juarez in the state of Oaxaca. Naturalists and collectors had worked in these mountains long before my wife Martha and I started assembling collections of amphibians and reptiles there in 1961 for the American Museum of Natural History.

This particular cloud forest is roughly 70 miles northeast of the state capital, Oaxaca de Juarez. It is not difficult to reach the forest, but because much of the travel is on an unpaved road that traverses the mountains, the trip usually takes four or five hours. Therefore, when Stuart Rowley, an ornithologist studying the avifauna of Oaxaca, accompanied me to the cloud forest in 1967, we set out at daybreak with the hope that we might reach the area before the clouds descended on it. I knew that salamanders were abundant near an elevation of 9000 feet and wanted to see if they occurred farther down. Mr. Rowley was less interested in salamanders than he was in the hummingbirds that nested in the mountains, but he was a particularly welcome companion for

BOAS–A PARADOXICAL FAMILY

BY CHARLES M. BOGERT



another reason, as far as I was concerned. For it was Mr. Rowley who discovered the dwarf boa.

Why had this extraordinary little boa – now known as *Exiliboa placata* – escaped attention until 1967? Presumably because it is not found outside this cloud forest. And like other forests of the sort, this one had been difficult to reach until a decade or so earlier. The high summits at the north end of the Sierra de Juarez are commonly covered with snow in the winter and often shrouded in clouds during the wet season of summer. Owing to the rugged terrain, steep hillsides, and heavy rainfall, travel in the area used to be slow and often hazardous. The area was accessible only to travelers on foot or horseback until logging roads were constructed. Even today, travel in modern vehicles is often slow in areas that become blanketed in fog, which develops as moisture-laden air currents from the Gulf of Mexico come in contact with the steep slopes and rise. Levels reached by the fog fluctuate from day to day, but the atmosphere is rarely clear. On occasion, however, clouds mask only the highest peaks.

Because relatively little heat from the sun reaches the ground in cloud forests, cool environments prevail. Nevertheless, there is ample moisture and enough light to support a luxuriant vegetation. Trees covered with orchids, bromeliads, ferns, lianas, and hordes of other epiphytes and parasites rise from a dense tangle of vines, tree ferns, shrubs, and herbs that cover the hillsides. Conditions seem much more propitious for frogs and salamanders than for reptiles, few of which seem to have become adapted to cope with the cool environments characteristic of cloud forests in this portion of Mexico.

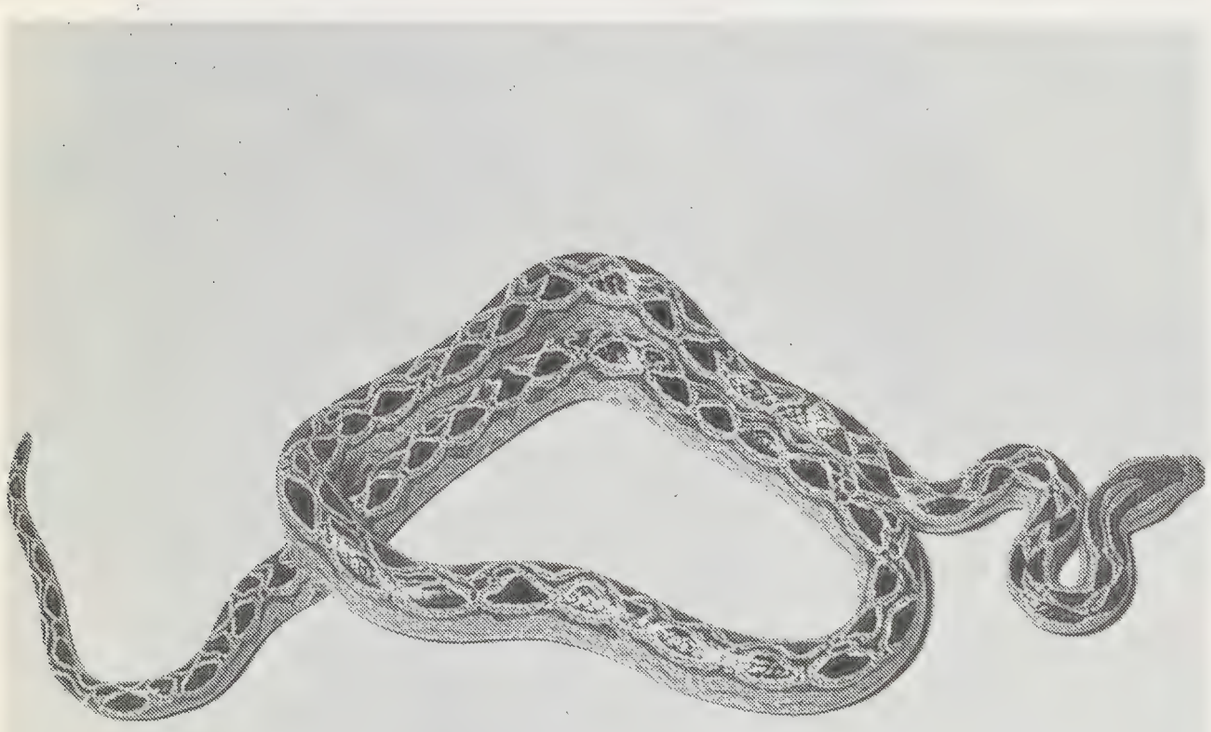
As a matter of fact, frogs were far more abundant than reptiles in the cloud forest where we found the boa. Other reptiles probably will be discovered in this area, which is inhabited by at least two species of lizard and a slender little brown snake belonging to a genus *(Rhadinaea)* that is widely distributed in the American tropics.

Mr. Rowley and I had been turning over rocks while searching for frogs in one of the clearings when he came upon the boa. I had just found a little brown snake when he called out that he had gotten a glimpse of a snake beneath a rock that he had started to overturn. Mr. Rowley, who had no qualms about seizing frogs, nevertheless drew the line at snakes. Consequently he dropped the rock back in place. Inasmuch as we had seen no other snakes in this cloud forest, I assumed that he had found a snake of the same species I had just placed in a sack. What I saw when I lifted the edge of the rock, however, was not a brown snake, but a black one – and to my astonishment, it proved to be a dwarf boa.

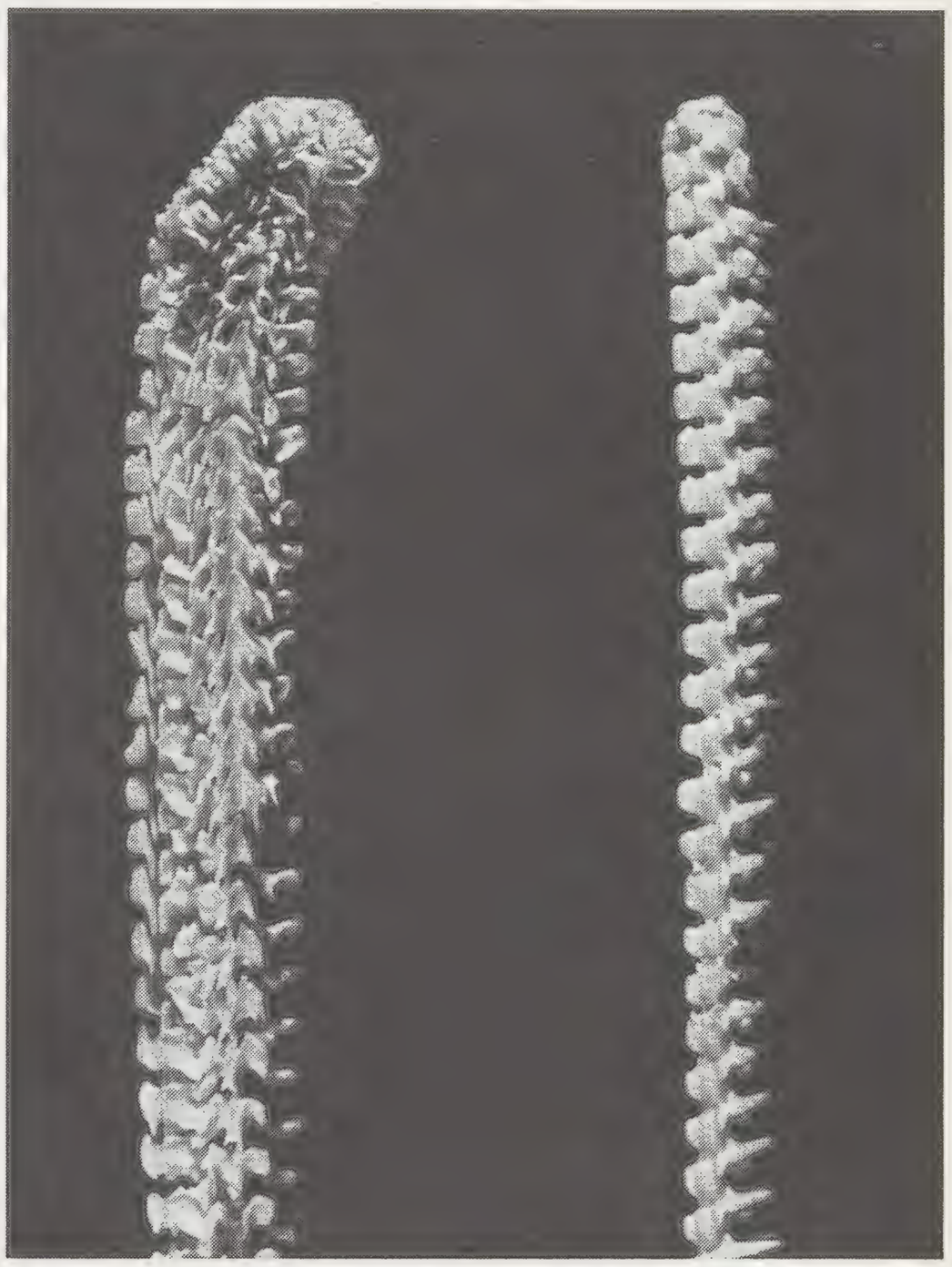
Most snakes found under rocks either crawl into crevices below the rock or flee into the adjacent cover when suddenly exposed to light. The boa remained motionless, however, with its body distended in the furrow that had afforded it

a passageway beneath the rock. When I seized the snake it made no effort to bite or to free itself. It merely drew itself into a sort of ball, with its head hidden beneath the folds of its trunk. At first glance it was a rather nondescript little boa scarcely more than 16 inches in length. It was shiny black, almost devoid of markings except for a thin, indistinct stripe above the lips, and a pure white blotch on the underside of the base of its tail. Like other boas, it moved slowly, and as it crawled on the ground it paused to investigate every hole or crevice, as though it were expecting to find shelter. It made effective use of its prehensile tail to hold onto twigs or branches when it was liberated in a shrub, but despite its ability to climb, the boa invariably descended to the ground, where it resumed its efforts to seek cover.

Undescribed reptiles continue to be found in those portions of Mexico that have only recently become accessible. If this snake had not been a member of the family Boidae, therefore, its discovery would have been more or less routine. But with the exception of the boa constrictor, boas are infrequently encountered in Mexico. Furthermore, most members of the family are restricted to the lowlands, and only five of the species had ever been taken north of Honduras. One of these, the rubber boa, *Charina bottae,* described in 1835, is the only species that reaches Canada, and it has not been found south of the San Jacinto Mountains in southern California. Only four of the species have distributions extending into Mexico therefore, and only one of these had ever been taken in an area as far above sea level as the cloud forest where we found the dwarf. With one exception, all these species had been described at least a century earlier.



Significantly, perhaps, the exception is also a dwarf, as well as the only boa previously known to inhabit cool, montane habitats in Mexico. This dwarf, which became known as *Ungaliophis continentalis,* was discovered in the Pacific lowlands of Guatemala and described in 1878. The species remained known only from the original specimen until 1924, when the second specimen was reported from Mexico. It had been found a few miles inland from the Pacific coast, in the Mexican state of Chiapas, scarcely 50 miles northwest of the place where the first one was discovered in Guatemala. No more specimens are known to have been found until 1966, when Roger Conant of the Philadelphia Zoo reported two additional specimens. Unlike the first two, however, these had been taken in the mountains. One of them had been obtained by Dr. Archie Carr of the University of Florida, who found it in a pine forest in Honduras at an elevation of 5000 feet. Mr. Conant discovered the other specimen in the pine-oak woodland on a mountain in Chiapas. The place where he found it is some 7000 feet above sea level and on the headwaters of rivers that flow into the Atlantic Ocean. When I visited the area in 1968, I found another one of these dwarf boas a few miles farther west.



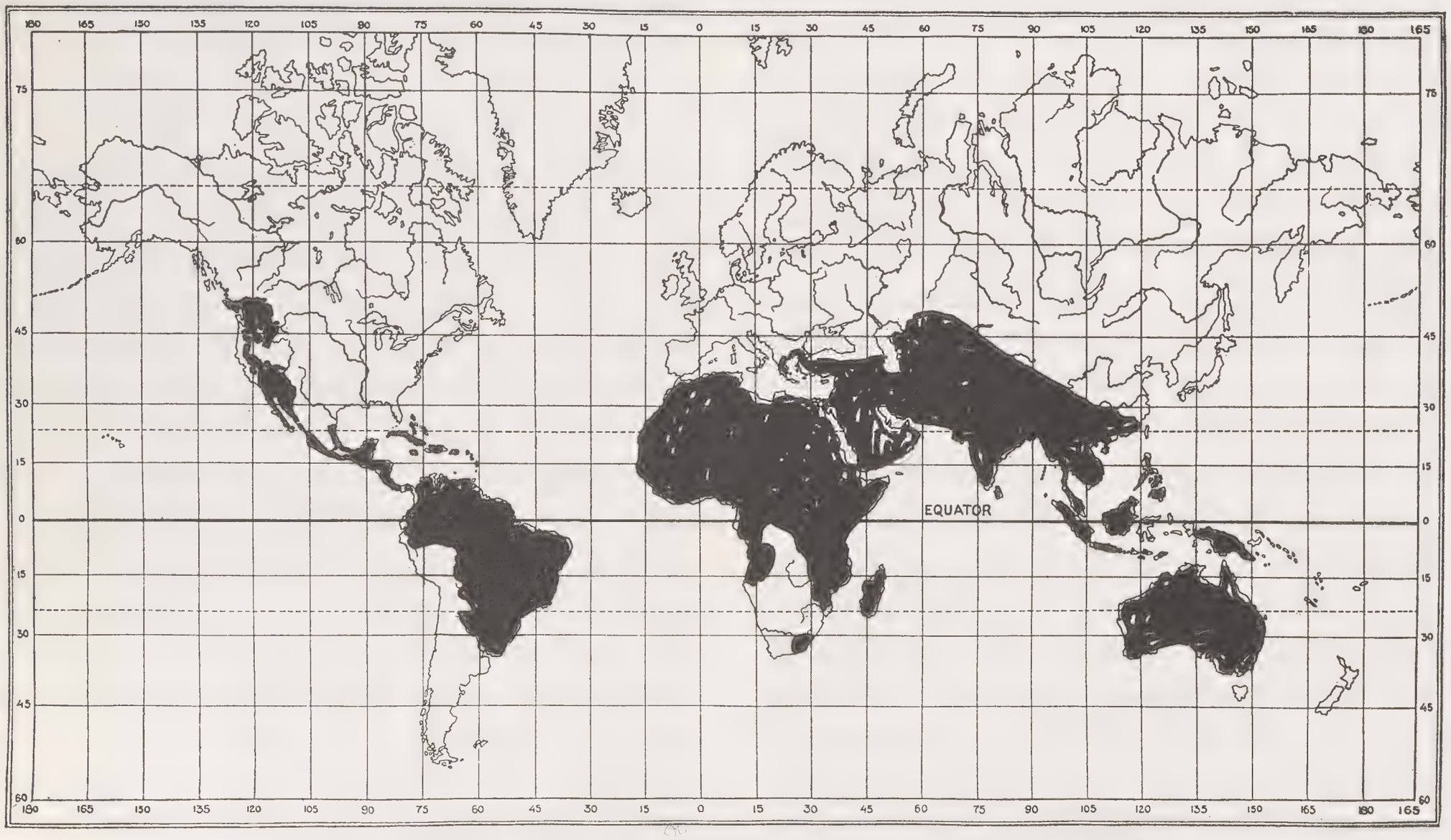
The Oaxacan cloud forest boa, *Exiliboa placata,* shown overleaf, was discovered in Mexico in 1967. At left is the Central American dwarf boa, *Ungaliophis panamensis.* Above, bones in the tails of boas show the modifications of the vertebrae of the Indian sand boa, *Eryx johni,* and the desert boa, *Lichanura roseofusca.*

As far as is known, only these four additional specimens of *U. continentalis* have been found since the first one was described 90 years ago. The rarity of these dwarfs is no less astonishing than the fact that two of them were taken in the

lowlands, whereas the other three were in the mountains. Snakes that tolerate environments ranging from near sea level to elevations of 7000 feet are usually relatively abundant and widely distributed. If this dwarf boa is continuously distributed from the Pacific coast inland to the higher mountains in Chiapas, Guatemala, and Honduras, however, it is difficult to explain why collectors so rarely find it. A closely related species, *Ungaliophis panamensis,* is nearly as scarce in collections. It is known from only three individuals obtained in the field: one from the lowlands of Nicaragua, one from a mountain in Panama, and the third from the Andes in Colombia. The only other specimens known to be in museum collections are four that reached the United States in banana shipments of uncertain origin.

Snakes (and lizards) inadvertently transported in bunches of bananas are nearly always species that forage in trees. This may be true of the dwarf boas in Central America and South America. If they are also nocturnal, as seems probable, it is evident that such small, slow-moving reptiles would readily escape detection, especially if they forage in the dense vegetation characteristic of the moist tropical lowlands. Such habits would, in part, explain why naturalists in Central America rarely find dwarf boas. Relatively few snakes are captured while they are abroad and active, however, and some are virtually never encountered on the surface. As any experienced collector knows, the secretive terrestrial snakes usually conceal themselves beneath rocks, in rotting logs, crevices, burrows, or in piles of forest litter. Many arboreal snakes, particularly the smaller species, hide in the vegetable debris that often accumulates on trees in the tropics. They may also squeeze themselves beneath the bark or crawl into epiphytes.

Not far from Rio de Janeiro, a Brazilian naturalist, Antenor Leitao de Carvalho, found two dwarf boas, *Tropidophis paucisquamis,* the same day. Both of them were hidden in bromeliads five to seven feet above the ground. The cup-like leaves of bromeliads often contain water, even during the dry season, when these plants afford suitable havens for many small amphibians and reptiles that would otherwise risk desiccation. Some frogs deposit their eggs in bromeliads, which contain enough moisture to serve as nurseries for their tadpoles. Ants, crickets, cockroaches, and many other kinds of insects, as well as earthworms, inhabit the larger bromeliads. Because so many of the creatures living in these epiphytes are seldom found elsewhere, entomologists and herpetologists have devoted a great deal of attention to bromeliads in Mexico and Central America. Thus far, however, neither entomologists nor herpetologists have found the dwarf boas of Central America in the sort of place frequented by the species in Brazil.



MAP SHOWING THE DISTRIBUTION OF THE FAMILY BOIDAE.

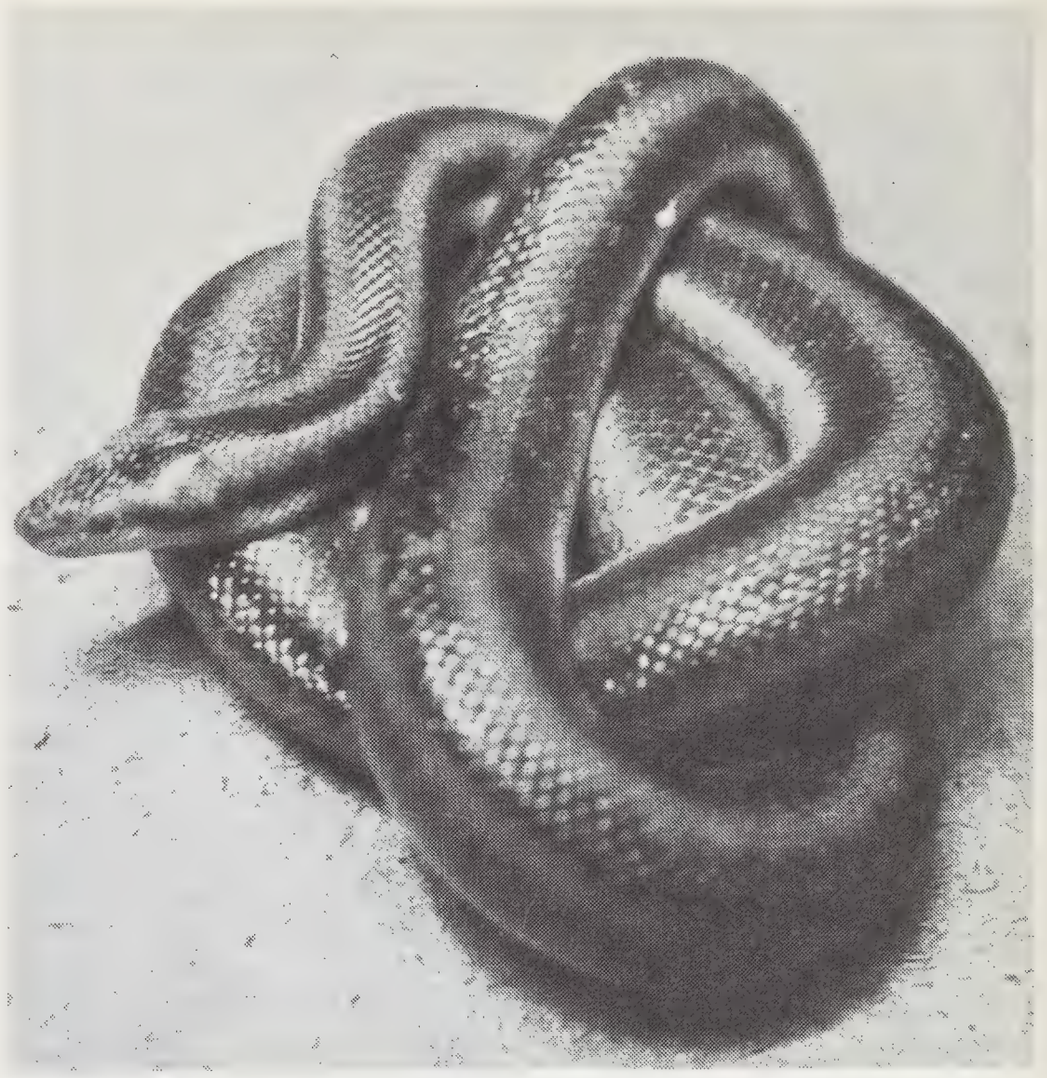
Have the dwarf boas of Central America evolved some peculiarly effective way of secreting themselves or are they actually rare? With the meager information assembled during the 90 years that have elapsed since the first dwarf boa discovered north of Panama was described, such questions cannot be answered satisfactorily. If these dwarf boas were more or less continuously distributed between Mexico and Colombia, however, many more specimens would presumably have found their way into collections. Even the

most secretive snakes are likely to be found accidentally by workmen clearing land or digging ditches, or by farmers and ranchers. If dwarf boas occurred in the vicinity of many towns and cities, naturalists would surely have gotten their hands on many more of these snakes. Their failure to do so can most readily be explained if we assume that the distributions of the dwarf boas have become disjunct. Perhaps a few isolated populations survive, but those in the intervening areas have disappeared.

This brings up the question of what might have wiped out some populations of the Central American dwarf boas. Conceivably adverse changes in the environment have been more severe in some areas then in others. Unfavorable trends in climatic conditions sometimes account for disjunct distributions. A steady decline in precipitation, for example, may lead to the survival of a few isolated colonies on humid mountains surrounded by lowlands too arid to support reptiles ill-adapted to resist desiccation. The occurrence of dwarf boas in upland as well as lowland habitats in Central America, however, rules out climatic change as the explanation for the extermination of populations. If these boas are as unevenly and sparsely distributed as the records suggest, other explanations must be sought. Possibly these boas were unable to cope with the parasites, predators, or competitors that may have invaded the area at some time in the past when boas were more widely distributed.

The distributional picture, as well as the fossil record, support the belief that competition played a significant role in the decline of the family Boidae. Before attempting to explain the peculiarities in the distribution of the family, however, we should consider other alterations in environmental conditions that have affected distributions. Topographical changes, for instance, most readily account for the occurrence of quite different dwarf boas on opposite sides of Mexico's Isthmus of Tehuantepec. The cloud forest in Oaxaca occupied by *Exiliboa placata* is roughly 300 miles northwest of the nearest population of the Guatemalan dwarf in Chiapas. The mountains inhabited by these two boas are separated by lowlands that as far as we know are no longer occupied by either species.

These two boas, though markedly different in appearance, possess similarities in their internal structure that point to a common ancestry but at the same time distinguish them from all other boas. We assume, therefore, that the dwarf boas of the past once occupied a far more extensive range that extended across the isthmus. We know, however, that land masses on opposite sides of the isthmus have been separated on occasion by the sea. The Isthmus of Tehuantepec was frequently much narrower in the past than it is today. Some

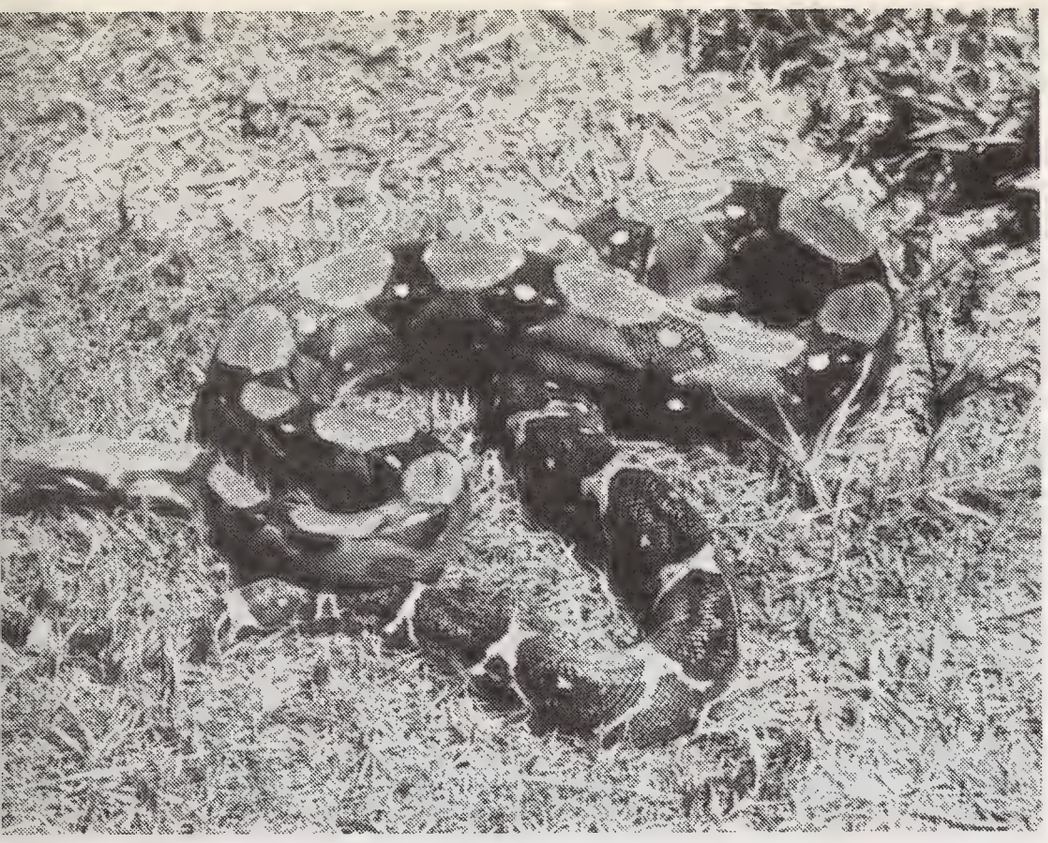


A desert boa, *Lichanura roseofusca gracia,* assumes the ball-like coil characteristic of small boas when they are disturbed.

20 million years ago, during the Miocene, and again perhaps 10 million to 12 million years later during the Pliocene, there was a marine connection between the Atlantic and the Pacific. When such conditions prevailed, the boas in Central America were effectively cut off from their relatives in Mexico.

Changes in the topography affect climates, which are of course subject to fluctuations for other reasons as well. We may never know precisely how the dwarf boa in Oaxaca became adaptively specialized, which it seems to be, as an inhabitant of moist environments in a cloud forest. This boa has had ample time to evolve its own peculiarities, whether its isolation from other dwarf boas dates from the Miocene or the Pliocene. In view of the sporadic occurrence of dwarf boas from Mexico southeastward to Brazil, the Oaxacan dwarf must be regarded as the peripheral remnant of an ancient dispersal. At least four, and possibly as many as six species of dwarf boas (of three genera, *Tropidophis, Trachyboa,* and *Ungaliophis)* survive in South America, not far perhaps from their center of origin. The diversification of dwarf boas, often accelerated by changes in climate and topography, may in fact extend back 50 million to 60 million years to the Eocene Epoch.

The evidence assembled by paleontologists strongly suggests that the boas occupied a wide range of habitats and exploited several modes of



The boa constrictor *(Boa constrictor)* ranges over South America and Central America; a length of more than 14 or 15 feet is exceptional.

living well before the end of the Eocene. Fossils identified as gigantic members of the family have been discovered in areas as remote as Egypt and Patagonia. Portions of the backbone resembling those of dwarf boas in Central America have turned up in Eocene deposits in Wyoming. At present boas are unknown in the United States east of Montana, but fossils found in Florida leave little doubt that members of the family once occupied this portion of North America. With such widely scattered traces of the family, it is difficult to escape the conclusion that boas were once far more abundant and more evenly and widely distributed.

In view of the ancient lineage of the snakes grouped in the Boidae, and their wide distribution in six continents, it is difficult to explain why scarcely more than 70 members of the family survive, or why the survivors are almost evenly distributed between the eastern hemisphere and the Americas. The living members of the group range in size from dwarfs little more than a foot in length to the giants among the snakes – the regal python of Asia and the anaconda in South America. All of the truly large snakes, those known to attain lengths exceeding 20 feet, are boas or pythons. No other family of snakes contains species with such an impressive range in dimensions.

Although the largest members of the family Boidae inhabit the tropics, some of the smaller species have distributions that extend as far north in Asia as they do in western Canada. Despite this evidence of adaptability, only two of the 33 species of snakes in Europe are boas, and the proportion is even lower in North America. Approximately 115 kinds of snakes have now been recorded in the United States, but only two of these are boas, one of which is shared with Canada, the other with Mexico. Snakes become somewhat more numerous in terms of species as one approaches the equator. More kinds of snakes are known from the small republic of Panama than from the whole of the United States. Only six of the Panamanian snakes are boas, however, even though the family fares somewhat better there than in Venezuela, where only five boas are included in the total of 117 species recorded.

If we turn our attention to the principal land masses in the eastern hemisphere we discover that similar situations prevail. Snakes flourish in southern Asia, which seems to be an ancient center of diversification for this group of reptiles. One family of snakes is restricted to India and Ceylon, and nearly all other families are represented. Only four boas, however, are included among some 360 species reported from this portion of the continent, not counting the sea snakes that abound off the coast.

As far as we can determine from the fossil record, venomous snakes evolved much later than the boas. Nevertheless, in terms of species, vipers and pit vipers are approximately eight times as numerous as members of the family Boidae in southern Asia. The vipers and pit vipers, relatively late arrivals, have out-diversified the boas and pythons in this region, as they have in many others. Is it merely because members of the family Boidae, with their primitive methods of subduing their prey by constriction, are becoming outmoded by snakes with more effective weapons?

The vipers and pit vipers, with their venom glands and movable tubular fangs, are unquestionably better equipped to kill their prey, as well as to defend themselves. If an elaborate venom apparatus had not been selectively advantageous, the vipers and pit vipers probably would not have evolved. Their acquisition of an effective food-getting mechanism accounts in part for the wide dispersal of vipers in Africa, Europe, and Asia, and the wide distributions of pit vipers in Asia and the Americas. Presumably these two closely related groups of venomous snakes failed to reach Australia only because this continent was separated from Asia before the vipers and pit vipers appeared. Relatives of the cobras presumably had evolved earlier, for they reached Australia, where they greatly outnumber the non-venomous snakes.

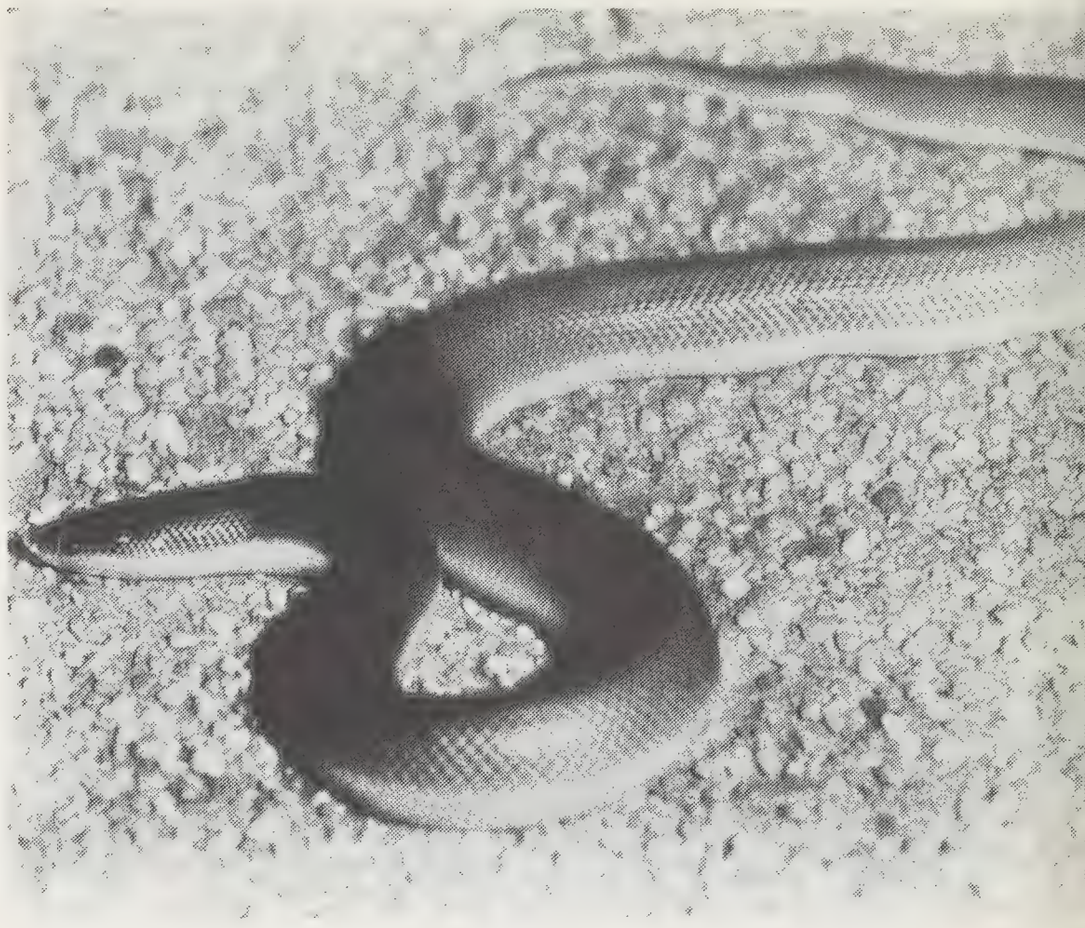
If we centered our attention on the snake fauna of Australia, we might infer that snakes with ordinary teeth were being superseded by those with fangs. Plainly this is not the case in southern Asia, where the dangerously venomous species comprise less than 13 percent of the snake fauna. In the United States, where 19 of 115 species are venomous, the percentage is only slightly higher. Other snakes that subdue their prey in much the same fashion as the boas, namely by means of

constriction, have been appreciably more successful than the boas. Are the kingsnakes, rat snakes, bull snakes, and their relatives, all of them constrictors, better qualified than boas to cope with existing environments? Were the boas more adversely affected than other snakes by climatic changes? Or did more adaptable snakes invade many of the habitats that boas and pythons had been exploiting without encountering any significant competition at an earlier date?

We scarcely need look beyond the West Indies for probable answers to some of these questions. The Bahamas can be reached in a matter of minutes if we fly over the Gulf Stream from Florida to Bimini. Climatic conditions on Bimini Island differ little from those near the tip end of Florida, an area well supplied with snakes, barely 50 miles to the east. As we have seen, the boas that once inhabited the peninsula of Florida have disappeared. Bimini, a mere sand-spit of an island too small to support a rich and varied fauna, nevertheless supports two boas, one of moderate size and a dwarf.

Many more kinds of snakes occupy the larger islands. At least 18 species inhabit Hispaniola, and boas, with four species represented, comprise about 22 percent of the total. Relatively few snakes are known to have reached Jamaica, but three of the seven species on the island are boas. Boas seem to have reached Cuba sufficiently long ago to have become diversified on the island since they arrived. A recent survey of the dwarf boas of the genus *Tropidophis* of Cuba suggests that eight or nine species now occupy the island, which is also inhabited by a much larger boa, *Epicrates angulifer.* Blind snakes, *Typhlops,* and a few representatives of the family (Colubridae) most widely distributed on the mainland have also reached Cuba. On this island, however, the snakes of the family Boidae outnumber all others. No region comparable in area to Cuba supports quite so many boas.

Trinidad, an island much smaller than Cuba, has a far richer snake fauna, consisting for the most part of the same species that inhabit the adjacent mainland to which the island was once connected. Boas fare little better in Trinidad than they do in Venezuela, in contrast to the situation on Hispaniola, Jamaica, Cuba, and other islands that were never connected to the mainland. A few snakes have gained access to these islands by means of over-water dispersal. Boas, among the earliest snakes to reach South America, were perhaps the pioneers on many islands in the West Indies. Other snakes arrived later, but the more primitive boas have not been swamped by potential competitors as they seem to have been on the mainland. As the boas declined on the continent, the islands became the principal havens for boas in the Americas. Approximately 36 species have been recorded in the New World, and it is no accident that half of these are restricted to the West Indies.

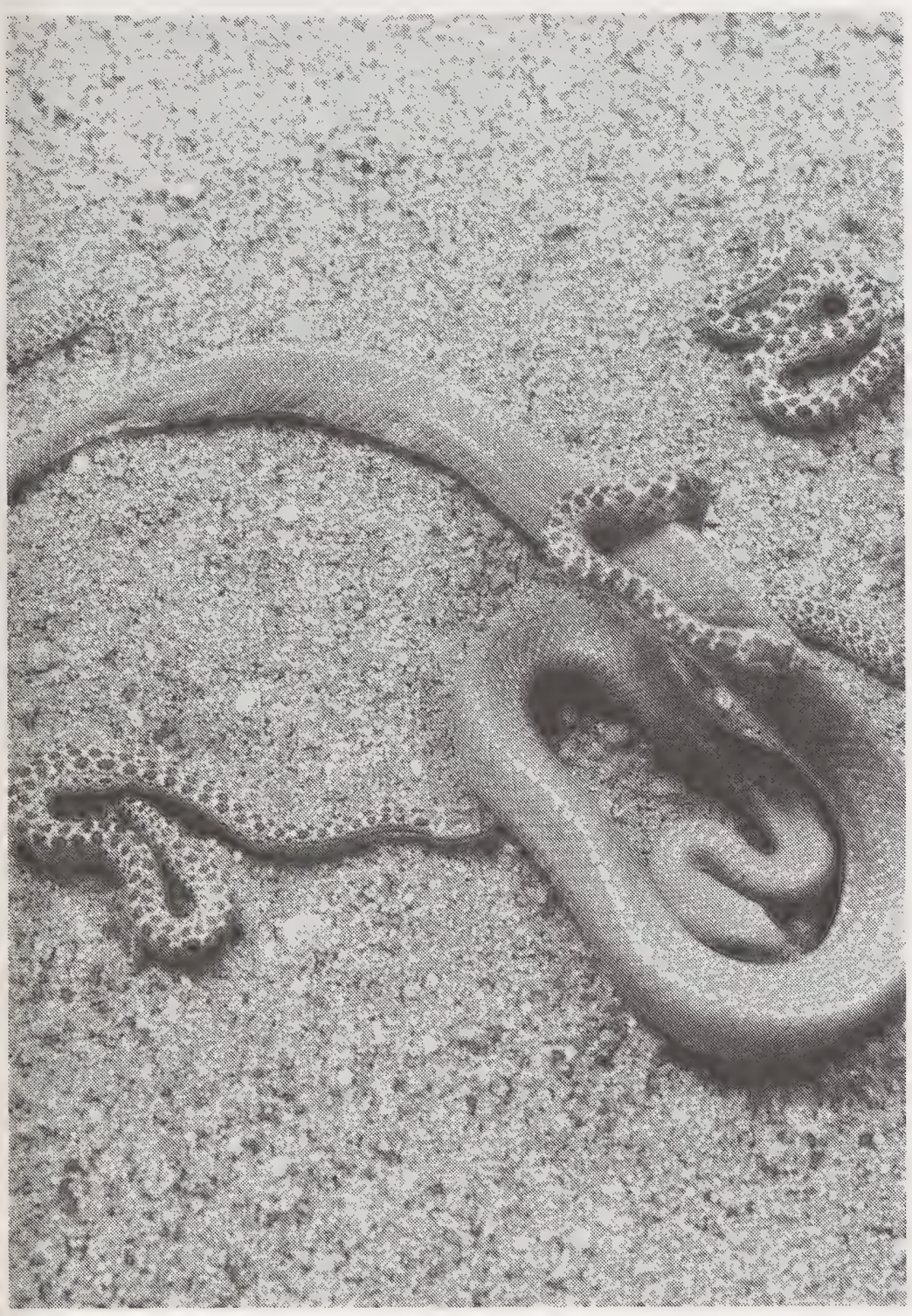


The pioneers on the islands are readily divided into two groups, the dwarf boas, *Tropidophis,* and the larger species, mainly those placed in the genus *Epicrates,* but including representatives of the boa constrictor that have reached some of the islands. The nearest relatives of these boas inhabit South America, which has evidently been the center of dispersal for nearly all of the boas that now survive in the American tropics. One exception, a member of the family that rarely exceeds a yard in length, was once known as the "Mexican python," *Loxocemus bicolor,* but it proves not to be a python at all. Though specialized as a burrower, it retains characters suggesting that it is the most primitive member of the family now extant, and not closely related to any other snake now living. It has an odd distribution, largely in the Pacific lowlands from Mexico to Costa Rica.

The rubber boa, *Charina bottae,* with a range wholly outside the tropics in western North America, seems to share its ancestry with the sand boas, *Eryx,* which are widely distributed in Africa and Asia. Their wide dispersal in Asia evidently extended across the Bering land bridge when favorable conditions prevailed in the area. Otherwise it would be difficult to explain how the boas on opposite sides of the Pacific came to have almost precisely the same odd modifications of the vertebrae in the tail. No other boas have the bizarre flanges that occur on the bones in the tail, which terminates in a blunt, burr-like configuration of bone rather than in a point. The tail is more nearly normal on the desert boa, *Lichanura trivirgata,* which occupies arid and semi-arid regions in northwestern Mexico and the adjacent portions of Arizona and California. Although the desert boa lacks distinctive features linking it to the sand boas, it seems nevertheless to be closer to

Asiatic members of the family than to other American boas.

The fossil record, helpful though it is, raises nearly as many questions as it answers. If the distribution of the boas extended all the way from Wyoming to Patagonia during the Eocene, are the boas now surviving relicts of dispersals initiated nearly 60 million years ago? Some species, notably the boa constrictor, which inhabits the lowlands from northwestern Mexico to northern Argentina, presumably have expanded their distributions fairly recently. The dwarf boas have not fared so



Shown on the opposite page is the small boa *Loxocemus bicolor,* erroneously called the "Mexican python." Above is a Bimini Island dwarf boa, *Tropidophis canus curtus,* an adult female with litter.

well on the mainland despite their relative abundance on the islands. Their diversification in the West Indies, attributable in part to separate colonizations, may date from the Oligocene, possibly earlier.

A study of the fossil snakes of Florida by Dr. Walter Auffenberg of the Florida State Museum, suggests that snakes resembling those now occupying the region began to arrive during the Miocene. Boas continued to flourish in Florida until the close of this epoch, roughly 13 million years ago. Following the invasion of the area by other snakes, boas rapidly declined, leaving few traces of their occupancy in sediments deposited later than the Miocene. While the boas continued to flourish and expand their distribution as they gained access to unoccupied islands in the West Indies, their relatives on the mainland were being replaced by snakes apparently better equipped than boas to exploit available habitats.

When viewed in the light of the fossil record, therefore, the wide but uneven distribution of the boas and their relatives becomes comprehensible. During the early stages in the evolution of snakes, with niches for such reptiles awaiting occupancy in many parts of the world, the boas encountered relatively few obstacles. Unhindered by the presence of other snakes in many of the regions they reached during their early dispersal, boas may have expanded their distribution at an astonishingly rapid rate. Every major land mass they reached afforded new opportunities for them to branch out and exploit an array of habitats. Before they reached their peak of abundance, boas had managed to establish colonies in every part of the world that was both habitable and accessible. To explain their occurrence on six continents we need not assume that boas were ever continuously distributed. We need only to assume that boas were actively expanding their distributions when avenues of dispersal were temporarily available from time to time.

Changes in the physical environment have undoubtedly affected the Boidae throughout the history of the family. Presumably the disappearance of populations, or the extinctions of species in some instances, came about as the result of changes in climate. The only major upheavel in the environment that might have affected boas in every major land mass, however, was the advent of the snakes that evolved after the family Boidae was nearing the peak of its dispersal. The boas were not of necessity confronted by the invaders in other parts of the world at the same time that the boas in Florida, for example, were finding themselves swamped. The more advanced snakes evidently reached some of the islands at a much later date, sufficiently late in the case of Cuba to allow the dwarf boas to continue their diversification.

Additional information may reveal flaws in this hypothesis. Whatever shortcomings it may have, it seems to account satisfactorily for the decimation of the boas on the mainland as well as their relative abundance in the West Indies. The same hypothesis may also explain why the dwarf boa, *Exiliboa placata,* survives in the isolated cloud forest in Oaxaca – in this instance largely because so few other snakes in the region are adaptively modified to tolerate such cool, moist environments. Assuming that the hypothesis is valid, the survival of boas on one side of the Gulf Stream and their decline on the other is not an enigma. Paradoxical yes, but no longer an enigma.

THE PLIGHT OF THE PEREGRINE

BY DAVID HANCOCK

The pristine luxuriant Canadian wilderness of the Queen Charlotte Islands is the home of the world's fastest flying bird – the peregrine falcon. Once enjoying the widest world distribution of any bird, the peregrine falcon has been reduced greatly in number in recent years.

The falcons have departed from much of northern Europe and England. Once a common breeder in the eastern United States, the peregrine falcon may now be extinct as a breeding bird east of the Rockies and south of James Bay.

To evaluate just how extensive is this decline of the peregrine falcon and other raptors, a symposium was organized in 1965 by the Department of Wildlife Management of the University of Wisconsin. With the financial support of the Audubon Society, the United States Public Health Service, and the American Museum of Natural History, 60 contributing delegates were brought from England, Finland, Switzerland, Germany, France, Africa, Canada, and the United States.

For four days, scientists, falconers, and naturalists documented and discussed the plight of some of nature's most awe-inspiring yet misunderstood creatures, the predatory birds. Bleak suspicions were confirmed. Most continents were undergoing – or already had experienced – drastic reduction of the avian predators. Some undeniable parallels and inferences emerged to suggest common causes of this global catastrophe.

Dr. Jean-Francois Terrasse of the National Museum, Paris, summarized the serious raptor decline in France as due largely to sport gunners and the widespread use of pesticide poisons. In England, the decline was more serious, the studies more thorough, and the inferences less speculative.

Derek Ratcliff and Ian Preast of the Nature Conservancy in England have found abnormal behavior patterns linked to reduced productivity and non-productivity in birds subjected to high levels of pesticides. Dead peregrines and spoiled eggs were found in nests and shown to contain alarmingly high residue levels. The stories from Germany, Switzerland, and the Scandinavian countries were equally bleak.

In North America, the drastic decline in predators, including the peregrine falcon, seems to have started about 1950 – just after the widespread introduction of pesticides.

On the British Columbia coast and particularly on the wild and rugged and windswept Queen Charlotte Islands, however, the story is today more hopeful. The great food wealth washed up from the pounding sea, which once supplied the

QUEEN CHARLOTTE ISLANDS

basis for flourishing Haida Indian villages and their rich culture, is the life source for the countless millions of sea birds that live on offshore islands. These sea birds, including the colorful puffin, penguin-like murres, and the tiny night birds, the Cassin's auklets, and ancient murrelets which once played an important part in the Haida diet, are also the staple diet of our specialized marine Peale's peregrine falcon (a race of peregrine). Nowhere else in the world but on the British Columbia coast can one stand on one spot and be within view of a half-dozen peregrine falcon eyrie sites at once. The peregrine falcons inhabit the most rugged islets, placing their eyries on some 200 to 300 foot precipitous cliffs – usually accessible to man only by ascending many feet on a rope suspended over the pounding surf. In a shallow scraping on a ledge under an overhanging cliff or tree root, the beautiful rufous red eggs of the peregrine are laid. Diligently, both birds incubate the eggs and brood the one to four young, protecting the progeny from pounding gales, predacious ravens, and crows – the latter of which may end up as falcon food if they are not careful.

Nest life is first a period of eating, sleeping, and growing. By one month of age the strong pinions that will eventually carry their sleek owners at speeds up to 200 miles per hour are just starting to grow. Then the nestlings practice exercising and wing beating, circulating blood into the developing feather shafts and strengthening wing muscles for that first flight – a flight that must enable them to reach safety on the nest ledge, for the parents will not feed the young on the ground. By six weeks of age the young are the size of the parents and ready to fly. During the next month they are taught to hunt by their parents, before they migrate southward.

The size of their nest ledge often limits the number of young produced. If the ledge is small, some young are usually accidentally knocked off and perish on the rocks below. Last year my wife, Lyn, and I rescued one very thin and emaciated chick from below such a tiny eyrie. Another chick was found starved to death on a ledge six feet below the regular nest ledge.

The peregrine feeds only on birds which it catches on the wing. On the Queen Charlotte Islands it preys solely on small colony-nesting sea birds, which it catches as the quarry dives seaward from its burrow home. Only where these sea birds nest in unnumbered thousands does the Peale's falcon breed.

It is this dependence on very specialized condi-

tions that has caused both concern and safety for our Queen Charlotte peregrine. These falcons are solely restricted in distribution to the north Pacific coast. Surplus birds produced here never go inland to establish breeding territories where different races of peregrines once lived.

We must be very careful to preserve the status quo of this highly specialized falcon so that it does not go the way of its relatives. Some conservationists advocate full protection for the Queen Charlotte Islands falcons. However, falconers want them for their age-old sport, and the British Columbia Fish and Wildlife Branch has carefully controlled the harvest of peregrine falcons by falconers in British Columbia since 1960.

The history of this harvest and how the present population came about perhaps sets an example of cooperative conservation between consumptive and esthetic wildlife interests.

Since 1955, when these birds were not protected by provincial law, falconers have been making annual pilgrimages to the Charlottes to collect their prizes. Some of the more responsible falconers soon foresaw that unlimited harvest of these falcons could not go on without adversely affecting the breeding population. In order to recommend management procedures, more biological data on falcon distribution and habits were needed. Several privately financed expeditions were undertaken. With the preliminary data at hand, the falconers presented a brief to the Provincial Fish and Wildlife Branch suggesting a permit system to limit the harvest.

These management proposals worked well until 1965. By that time falconer requests for birds were above what first "guesstimates" considered to be safe harvest limits. Also hawks, eagles, owls, and falcons had by then become protected by provincial law. The Fish and Wildlife Branch imposed greater harvest restrictions and decided it would have to conduct its own more extensive and long-range surveys. First, this would add to the basic biology of the falcon and would permit evaluation of the effect of management proposals on the wild birds.

Many individuals and organizations have cooperated with the Fish and Wildlife Branch in gathering the data on which the regulations are based. The Federal Fisheries have generously supplied weather patrol boats and skilled crews; University of British Columbia zoology students have contributed assistance and notes; the Raptor Research Foundation has supplied investigators.

The permit system controls the number of birds collected and the parts of the Charlottes from which they may be taken. In 1968 it favored British Columbia residents, allowing them one or two birds. No non-residents were given permits and no birds for falconry purposes were allowed to be exported from British Columbia. A restriction on all permits is that at least one bird must always be left in a nest to encourage reoccupancy of the area; that the permit holder must collect his own birds; and that no young can be taken before a certain day each year.

Up until 1967 the number of young per pair and the size of the nesting population remained relatively constant, according to regional game biologist Don Blood. My own studies suggested that possibly signs of overharvest were showing and I recommended a temporary halt to harvesting or a very minimal harvest. The 33-bird limit set by the Fish and Wildlife Branch for 1968 still exceeded my recommendation.

In view of the low harvest success by falconers in 1968, and several illegal collecting activities by Canadian and United States falconers, it seems reasonable to suspect the British Columbia Fish and Wildlife Branch will at least temporarily close or very tightly limit the harvest this year. If some harvest is permitted there is perhaps greater likelihood of the department justifying the costs of the necessary studies and patrols on those resources that presently offer no revenue to the province. (As of April 1969, the Branch planned a harvest of 10 birds to be distributed to falconers.)

According to Chief Biologist Glen Smith of the British Columbia Fish and Wildlife Branch, the basic philosophy behind the management of the Queen Charlotte Islands peregrines is the Branch's policy of priorities. Of first concern is the welfare of the peregrine; second, consideration for scientific research; and under the third priority, the excess crop of birds is available to falconers. With these guiding principles and the continued cooperation of conservationists, falconers, and Fish and Wildlife biologists, our peregrines have perhaps a better than even chance of survival.

The Canadian Wildlife Service in 1963 commissioned me to collect several peregrine falcons for

In the nest, the male peregrine falcon turns the eggs, which results in even incubation.

their experimental project using falcons to scare nuisance birds from airports. After termination of this project in 1965, the birds were turned over to Frank L. Beebe of the Provincial Museum, Victoria, British Columbia, to maintain for breeding purposes.

This was the first time in North America to my knowledge that an adult pair of peregrines had been confined together for the breeding season, and it produced results. Three eggs were laid over a five-day period in 1966. After 40 days of constant brooding by both parents and mounting anxiety by the onlookers, the eggs were removed and found to be infertile. It was disappointing that no young were fledged but promising, and somewhat rewarding, that the project had proceeded this far, so quickly.

There were unexpected results in 1967. The Beebe birds succeeded in producing four eggs by early April. These were removed to an incubator in hopes of inducing a second clutch, which materialized four weeks later. The first clutch was infertile. Again incubation was assiduously handled by both parents. On the thirty-second day, while Mr. Beebe's hopes were diminishing, he checked the nest ledge and before his eyes, with the female falcon standing over the eggs, one hatched, with its tiny wet and feeble chick.

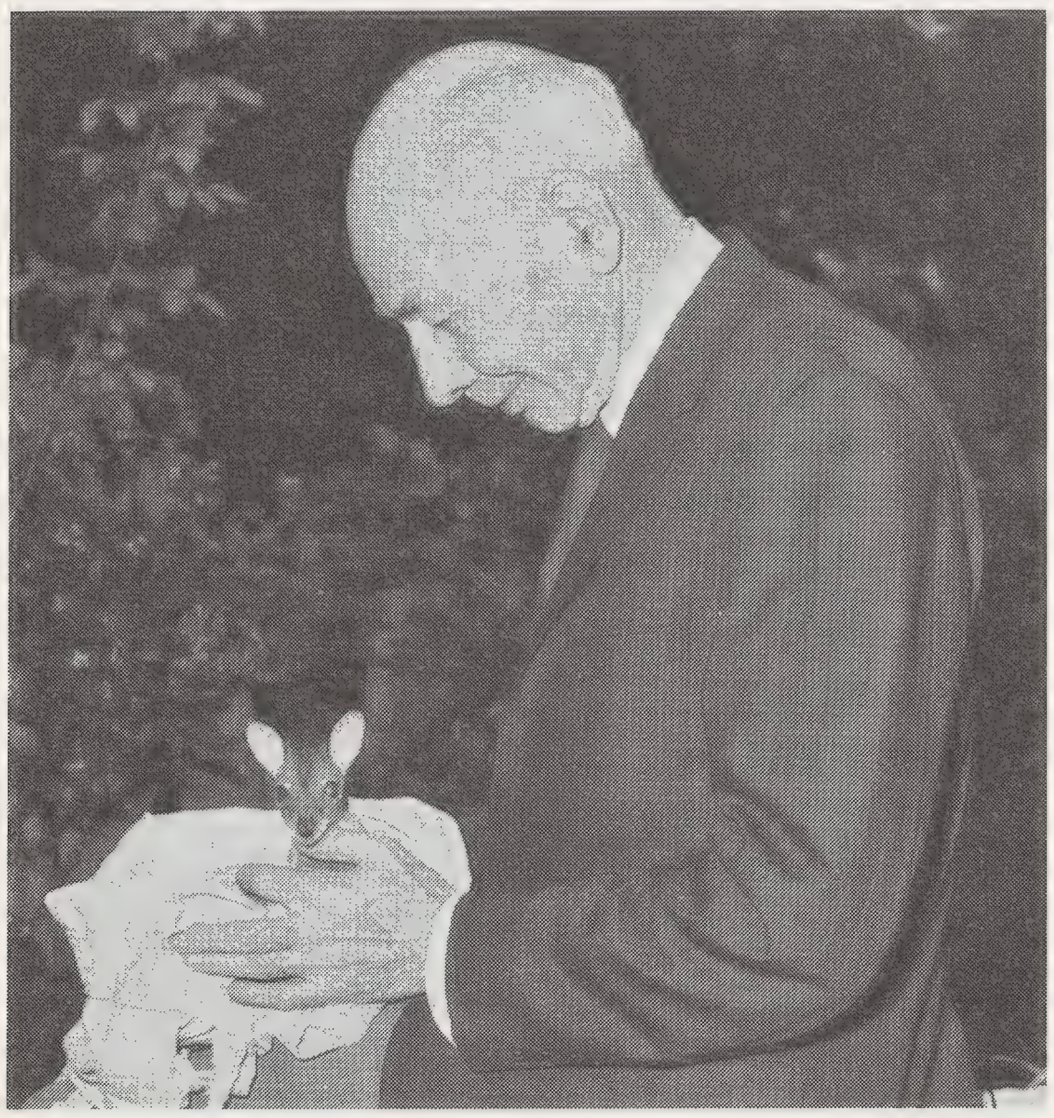
Heartbreaks were to follow. Before a feeding had taken place, the chick died. Anxiously we awaited the next arrival. Three days passed. The eggs were checked. One was well pipped, and peeping and movement was detected in a third. Two more days of waiting followed, and on the third day the female was seen pecking at a crushed egg and carrying it in her beak to a ledge 12 feet away. The male immediately flew over, pecked at it a few times, and then deliberately held the egg over the edge of the ledge and let the shell and its dead embryo drop to the ground. Our concern rose. The other egg had been visibly pipped for two days now. There seemed only one thing to do — try to hatch the remaining egg ourselves. Carefully, and with the aid of water, the pipped end of the shell was opened and the chick freed. The extreme weakness of the chick led to its death during the first night. The fourth egg was infertile.

Hopes for this past summer were dashed when Mr. Beebe's adult male falcon died. However, a pair of captive Peale's falcons in Portland, Oregon, successfully raised one young, and one or two more young are reported to be rapidly gaining weight in Germany. Aviculture of the peregrine falcon has surely advanced one enormous step. And with refined avicultural techniques, captive propagation may significantly contribute to the conservation of these magnificent aerial hunters. By removing eggs as they are laid, the parents may re-lay and more than one brood could be available each year from each captive pair.

On our Queen Charlotte Islands falcon surveys last year we stopped briefly at Skedan's Point. All that now remained of a once-mighty Haida village, spread out beneath gigantic Sitka spruce, were empty and decaying burial poles. It is to be hoped that the older Charlotte inhabitant, the Peale's peregrine falcon, does not follow this same line of abuse. Under the watchfulness of the Fish and Wildlife Branch, and with continued cooperation by falconers, conservationists, and aviculturists, our peregrine may not only hold its own, but through captive propagation show the way to increasing the number of falcons in other areas.

The female peregrine stands guard by the nest (at right): below, the pair of adults shares the feeding of the four-day old chicks.

animal kingdom
NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION
REPORTS



Lee S. Crandall, General Curator Emeritus of the Bronx Zoo, was photographed several years ago with a young friend, a baby wallaby.

LEE SAUNDERS CRANDALL
January 26, 1887 – June 25, 1969

"Dean of American zoo men" was the term often applied to Lee Saunders Crandall after the publication in 1964 of his book, *The Management of Wild Mammals in Captivity*. Ten years in the writing and a third of a million words long, it was a distillation of half a century's close observation of the care, feeding, housing, reproduction, and longevity of animals in the Bronx Zoo with copious references to captivity history and practices in other zoos in the United States and abroad. The work was commissioned by the New York Zoological Society after Mr. Crandall's retirement in 1952 as General Curator of the Bronx Zoo, and was published by the University of Chicago Press. It immediately became known in the zoo world as "the zoo men's bible."

Mr. Crandall's career with animals began long before he joined the staff of the Bronx Zoo as a student keeper in 1908. Born in the upstate village of Sherburne, New York, on January 26, 1887, he was the son of a country doctor. Young Crandall accompanied his father on his horse-and-buggy rounds of the countryside and captured owls, turtles, snakes, and anything else he could find to be added to his private zoo at home. At the age of 15 he went into business for himself as breeder and exhibitor of Sebright and Cochin bantams, maintaining his solvency only because his father paid for the "Crandall and Company" letterheads he ordered.

As the son and grandson of a doctor, he was expected to follow the same career and was enrolled in Cornell Medical School in 1907. His own inclinations were for working with wild animals, however, and in 1908 a casual conversation with his class president, a nephew of the treasurer of the New York Zoological Society, led to an interview with Dr. William T. Hornaday, the first Director of the Bronx Zoo. Dr. Hornaday offered him a job as a student keeper, rotating duties in the mammal, reptile, and bird departments.

In his book, *A Zoo Man's Notebook,* published in 1966, Mr. Crandall said of that interview: "He did not say anything about payment, and so I assumed that this glorious opportunity was free – I would not have to pay for the privilege he offered."

His duties – "to do what I was told to do" – were indeed without payment on either side, but in the fall of 1908 the late Dr. William Beebe, then the young Curator of the Bird Department, offered him a permanent job as his assistant at a salary of $30 a month. "Such happiness comes few times in a lifetime," Mr. Crandall commented in the *Notebook.*

Almost immediately he left for British Guiana with Dr. Beebe where he was expected to make a collection of birds. Dr. Beebe later reported of his young assistant that he had gotten himself bitten by a perai (a savage fish), had wrestled a deadly six-foot bushmaster for ten minutes until help came, and had come in from the field one day with a live bird in each hand and one in his mouth. In the end, he captured some 300 birds of 50 species and brought them back to the zoo.

That and subsequent tropical collecting trips were eclipsed by Mr. Crandall's expedition to the interior of New Guinea in 1928 to collect birds of paradise for the Bronx Zoo. Afoot, with John "Pop" Ward, an Australian field naturalist, as his companion and a train of native bearers for the collecting gear, he penetrated the Owen Stanley Mountain Range and eventually came out with 40 birds of paradise, most of which had never been seen alive in the United States, and about 200 other birds and mammals. The steamer on which he departed from Port Moresby was wrecked on a coral reef and although the other passengers were soon taken off, Mr. Crandall and his charges rode out a storm for six days until they were rescued. He arrived in New York with his collection intact.

Mr. Crandall became Curator of Birds at the Bronx Zoo in 1920 and was General Curator, in charge of mammals and birds, from 1943 until his retirement in 1952. For the next 12 years while he was writing *The Management of Wild Mammals in Captivity* and seeing it through the press, he kept regular five-days-a-week hours in an office in the Bronx Zoo and even after publication of his major book continued to amass file-card notes of significant events in zoos all over the world.

His detailed memory of individual animals was legendary among zoo people. At the age of 79, turning through a new book on waterfowl, he questioned the color of a bird's eye in the artist's drawing. He had seen the species only once, on a visit to the London Zoo in the 1930's, but reference to the original technical description showed that his recollection was right and the artist was wrong.

Mr. Crandall was the author of some 300 scientific papers, mostly on birds, and of *Pets and How to Care for Them* and *Paradise Quest* in addition to *The Management of Wild Mammals in Captivity* and *A Zoo Man's Notebook.* He was secretary-treasurer of the American Committee for International Wild Life Protection, and a Fellow of the New York Zoological Society, the New York Academy of Sciences, and the American Ornithological Union. The Zoological Society of London made him a Corresponding Member, and he was an Honorary Member of the Zoological Society of San Diego, the American Institute of Park Executives, the International Union of Directors of Zoological Parks, and the Avicultural Society, as well as a member of the American Society of Ichthyologists and Herpetologists, the American Society of Mammalogists, and the Linnaean Society. In 1965 he was awarded the Everly Gold Medal of the American Association of Zoological Parks and Aquariums.

He is survived by his wife, Celia Dowd Crandall, and one daughter, Mrs. Sylvia Dudley.

New Aquarium Opens

A new landmark was added to Boston's historic waterfront this summer as the $6-million New England Aquarium opened on Central Wharf.

Opening ceremonies were highlighted by a parade through Boston's financial district and a nautical salute from harbor vessels.

Built by funds raised through public subscription from interested individuals, corporations, and foundations in New England, the new waterfront facility has been under construction since October, 1965. The aquarium was fully operational on opening day, June 20, with the exception of the giant 200,000 gallon Ocean Tank which was expected to be ready this autumn.

The aquarium has 70 internally-illuminated fish tanks that give the only light to its semi-dark exhibit areas, kept purposely light-locked to add dramatic emphasis to the marine animal and plant life.

Portions of the four-level aquarium building have also been set aside for continuing programs of marine research and education in the aquatic sciences.

The new aquarium has 80,000 square feet of space with each of its exhibit floors linked by gradually inclined ramps. In addition to the large fish tanks, each major exhibit area is divided by colored panels which carry further explanations and pictures. The entire west wall is used for huge silhouettes of various members of the shark family illuminated by ultraviolet light. Overhead is a 30 foot skeleton of a right whale.

The new aquarium, which had a membership of more than 10,000 before it opened its doors, was first organized in 1957. It is part of the first phase in a redevelopment of Boston's waterfront area.

Geared to handle 1,000 visitors per hour, the New England Aquarium is open 9 a.m. to 5 p.m. weekdays; 10 a.m. to 6 p.m. on Saturdays; and 12 noon to 8 p.m. Sundays.

THE bookshelf

BEEVER & COMPANY. *By Joseph A. Davis. Drawings by the author; photographs. 203 pp. Harper & Row, New York, 1969. $5.95.*

In a country as large as this, the chance that some casual friend will turn out to be a lutraphile is about the same as, say, being blown up by a boiler explosion. Still, the prudent man will take precautions; he will not admit steam engines into his home, and he will buy *Beever & Company*. At $5.95, lifetime insurance against being called upon (in the name of friendship) to transport, baby-sit, doctor, and, in short, bear with an otter is ridiculously cheap.

In my youth, certain poolroom hangers-on were referred to by respectable members of the community as cigarette fiends; they were always smoking coffin nails, couldn't leave them alone. Joseph A. Davis is an otter fiend. He can't leave otters alone nor – God knows – do they leave him and his house and his friends alone. And yet, oddly enough, they all seem to have a lot of fun at the same time they're having heartbreak and furniturebreak. It's curious.

Mr. Davis – no, *Joe* Davis; how can you be formal about a man who shares bed and bath with otters? – Joe Davis is Scientific Assistant to the Director of the New York Zoological Park, with particular interest in ethology. He defines ethology as "the business of seeing what an animal does, and trying to discover the significance of its behavior in terms of the animal's biological make-up." This, he adds, "has been my excuse for keeping animals at home with me, or one of my excuses, anyway."

The truth is, he just plain loves otters and while the normal reader may shudder his way through *Beever & Company* and be glad the otters are in a book and not in his lap, under his bedclothing, in his toilet bowl, or on top of his bookshelf, he too may find himself falling in love with them – in the way, of course, that we have of falling in love with vigorous characters in a book without necessarily wanting to have them live with us. For every otter is different, requires different understanding and techniques, has its own vocabulary (Joe Davis can *talk* otter!) and its own ways of outwitting and exasperating man, and those personality traits inveigle themselves into our minds, seize on our scientific curiosity, and end by engaging our deep affection. Outside a work of fiction, I cannot recall a chapter about the death of an animal that moved me so much as Joe Davis's restrained account of the death of Beever from feline enteritis while he was absent in the Southwest.

Beever & Company is a catastrophe-by-catastrophe report on the otters that have lived in his home in New Jersey, wrecked his furniture, sometimes bitten his friends, romped through his living room, and gradually revealed the secrets of otter behavior in sickness and health to Joe's tolerant and discerning mind. The friends who come into the story are, for the most part, lutraphiles themselves and evidently accustomed to being called upon to come to the rescue when emergencies arise. There are, perhaps, more otter fiends than the rest of us realize, and the danger of contracting a friendship with one more than hypothetical. Well, *if* it happens, this is still a good book to have at hand; you will learn what to expect, and usually how to cope with it.

William Bridges

Correction: The caption of a photograph on page 14, ANIMAL KINGDOM, June, 1969, incorrectly identified the bat depicted as *Myotis lucifugus.* The bat pictured was *Antrozous pallidus.* The error occurred in printing of the issue and was not the fault of the author.

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DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

The Monkey Eating Eagle

Pithecophaga jefferyi

Until the very last decade of the nineteenth century, naturalists were unaware that a huge, forest-dwelling eagle was to be found in the Philippines. On his second trip to study the birds of these islands, in 1896, John Whitehead collected a large eagle that had been observed flying near his camp on Samar Island. Although the species was new to Whitehead, he wrote the following about it in his field notes: "He (the eagle) is well known to the natives as a robber of their poultry and small pigs, but chiefly as a destroyer of monkeys, which are the only animals sufficiently abundant to support such a large bird." When this specimen was officially described, it was named, appropriately enough, the Philippine monkey eating eagle, *Pithecophaga jefferyi*. (The specific name *jefferyi* was in honor of Mr. Whitehead's father, who had financed his expeditions.)

In a way, this discovery was the beginning of the end for one of the world's most spectacular birds. Today, a little more than 70 years after it was first sighted in the wild by John Whitehead, the monkey eating eagle's status has become extremely precarious. So much so that the RED DATA BOOK of rare and endangered birds, published by the International Union for Conservation of Nature and Natural Resources, lists it as: "Very rare and decreasing in numbers with cause for great anxiety about its future." It is believed that fewer than 100 of these great, shaggy-crested birds still exist in the wild.

The RED DATA BOOK lists trapping for export to zoos and the bird's local popularity as a mounted specimen among the major reasons for its decline. So few have come to zoos that land clearance for farming and logging for lumber in its mountain forest habitat are probably the important culprits. The monkey eating eagle once found in the tall kapok tree forests of Luzon, Samar, Leyte, and Mindanao is now confined to Mindanao, with a few birds reported from Luzon.

The general picture of this rare bird as a captive has not been encouraging. With the exception of the Bronx Zoo's two females in the collection since 1961, a female living in the Philadelphia Zoo since 1956, and a male in the St. Louis Zoo since 1963, the average life span of monkey eating eagles in United States zoos has been less than three years. Lack of year-round, heated facilities, plus the paucity of specimens in captivity to choose from, for pairing, has made the chances for captive propagation very slim indeed. One pair did attempt to breed, in the San Diego Zoo in 1954, but the eggs proved infertile and the female of the pair was subsequently lost.

The monkey eating eagle is protected by law in the Philippines, but only a forceful conservation program there can save it from the fate of the dodo, the great auk, or the passenger pigeon.

JOSEPH BELL

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ABOUT THE COVER

Front: Leopard seal *(Hydrurga leptonyx).* One of the four species of earless seals found in the Antarctic, the leopard seal is a rugged, fierce predator and a scourge of south polar penguin rookeries.
Dr. Richard L. Penney, while studying Adelie penguins, has spent considerable time observing this unusual and seldom-seen seal. He writes of his experiences on page 2.

Back: Clownfishes *(Amphiprion* sp.*)* and "host" sea anemone, native to the Indian Ocean.

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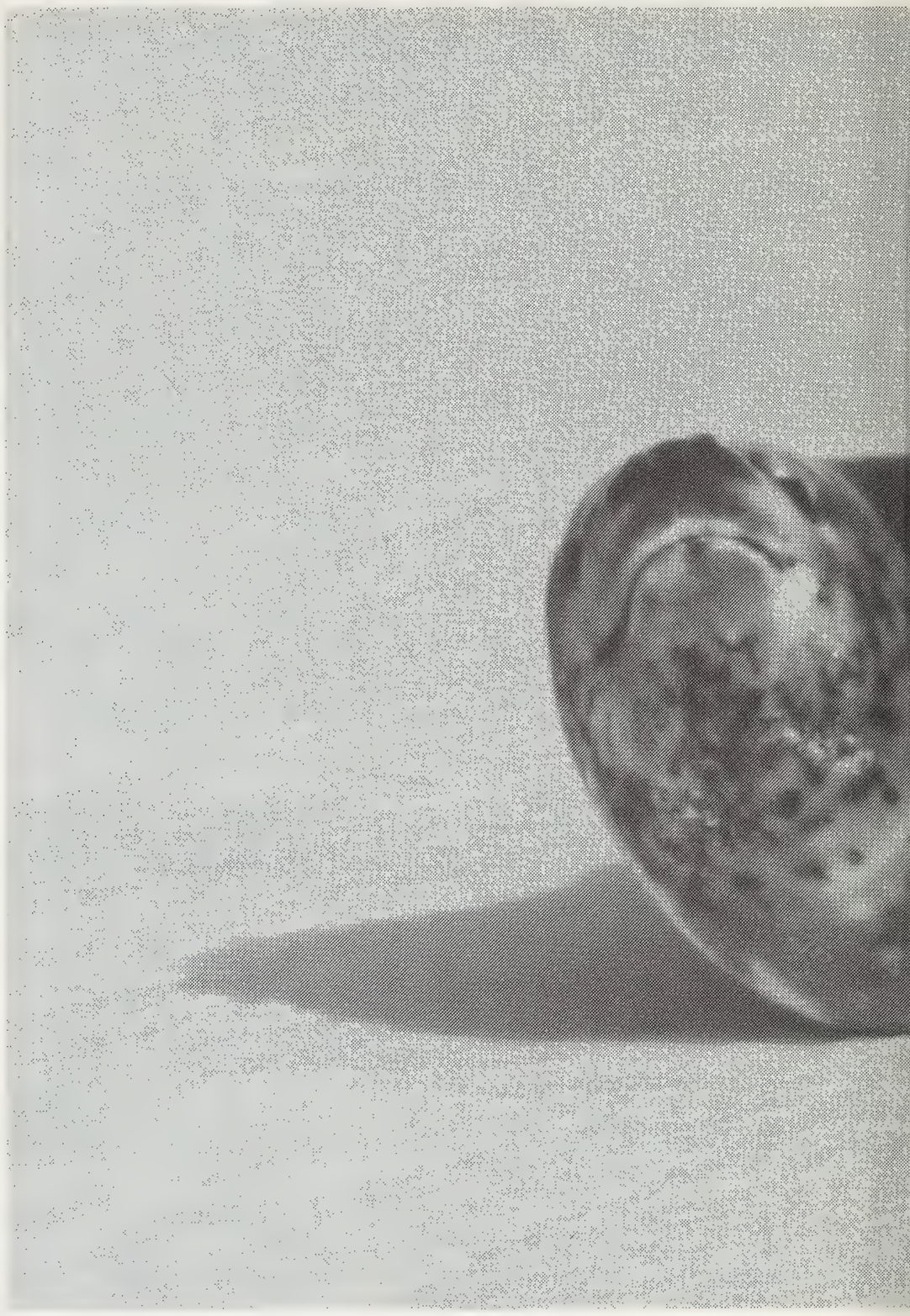
THE LEOPARD SEAL —

by Richard L. Penney



A leopard seal basks on the sea ice under the Antartic sun. This fierce predator of the south polar seas can reach a length of 13 feet and weight up to 1,000 pounds.

The leopard seal is one of the most exciting animals found in Antarctica. This seal, superbly adapted to the aquatic south polar environment, preys voraciously on Antarctic penguins. Experienced Antarctic hands keep a watchful eye when leopard seals are around, for these fierce predators are not very good at discriminating between man and penguin as a potential source of nourishment.

Very little is known about the leopard seal. Early explorers encountered it in the southern seas and made due notation of the creature's "fierce temperament," but they provided little detail. To my knowledge no one has seen this seal in courtship, mating, or any other type of intraspecific behavior.

The leopard seal is truly a pelagic animal, wandering the cold waters of the south, thereby keeping from science such secrets as where and when it gives birth. Collection records indicate that adult females are 10 percent larger than males — a rather unkind fact in the pinneped world. The leopard seal weighs up to 1,000 pounds and can reach 13 feet in length; combine this size with immensely impressive dentition and quickness of movement and you have an animal that merits more than a little attention.

During the past 10 years I have had several encounters with leopard seals and I find my attitudes have evolved from indifference to extreme dislike to great respect. In March 1959, I was a green field biologist undertaking a two-year study of Adelie penguin behavior at Wilkes Station, Antarctica. On March 2, I took the dog team and sledge out onto the sea ice about two miles north of the station, where a seal had been killed to feed our every-hungry sledge dogs. Being inexperienced, I assumed I was flensing a Weddell seal and was quite excited about finding Adelie penguin feathers in the stomach of the dead animal. Weddell seals are docile, fish-eating denizens of the coastal Antarctica and I could not recall any notation in the literature about Weddells preying on penguins.

As I quitely examined this, my first seal carcass, I heard a loud expiration of air from the ice edge 10 feet away. Up popped a large head followed by about a 10-foot body, spotted silver and black. I stepped back a little and took a few pictures as the live seal came up to the carcass, sniffed around, looked me over, and then sleekly returned to the water. I resumed flensing the dead seal, a process that took me a surprising two hours. When I finally loaded the carcass on the sledge, the second seal was still cruising up and down the ice edge. Several months later photographs confirmed that both the dead seal and the live seal had been leopards and that I had been indifferently interacting with a potentially dangerous beast.

SOUTH POLAR PREDATOR

No more leopard seals were seen at Wilkes during the winter months. In late October 1959, shortly before the spring return of the Adelie penguins from their wintering areas, with some other biologists, I encountered five leopard seals basking on the sea ice near Wilkes. By now the difference between the leopards and Weddells was clear in my mind. The next day a companion and I returned and found three leopards on the ice and a fourth one swimming along the ice edge, showing great interest in five nearby emperor penguins. The emperors avoided going into the water, even when we chased the birds to band them with identification tags used in research.

Keeping our husky dogs supplied with seal meat was my spring, fall, and winter job at Wilkes. At that time it was customary to use seal meat as dog food. Whenever possible, however, the seal-killing was combined with scientific collection and study. Fortunately in present day Antarctic operations, such depredations on the indigenous fauna are discouraged and husky dogs have been replaced with vehicles and aircraft. This is progress – but the dog lovers call it a shameful loss of tradition.

During 1960 I wandered many miles from the station on foot and found it convenient to carry a .38-caliber revolver, in case I should unexpectedly encounter a seal for use as food. The .38 was powerful and adequate for dispatching Weddell seals, which are easily approached.

On one of my treks, I spotted a seal two miles out on the sea ice. I approached within 10 feet of the seal, which turned out to be a large male leopard, and fired the pistol at a point just behind the animal's left eye. Now began a sad story. The seal moved rapidly toward me, then turned toward the ice edge 30 feet distant. I closed in on the seal and fired five more bullets at its head, missing once. To my great distress, this did not keep the seal from the water and I was forced to see a seriously wounded animal depart, gushing blood. This unfortunate incident made me angry with the leopard seal and even more angry with myself. Never again would I use a revolver to dispatch a

leopard seal.

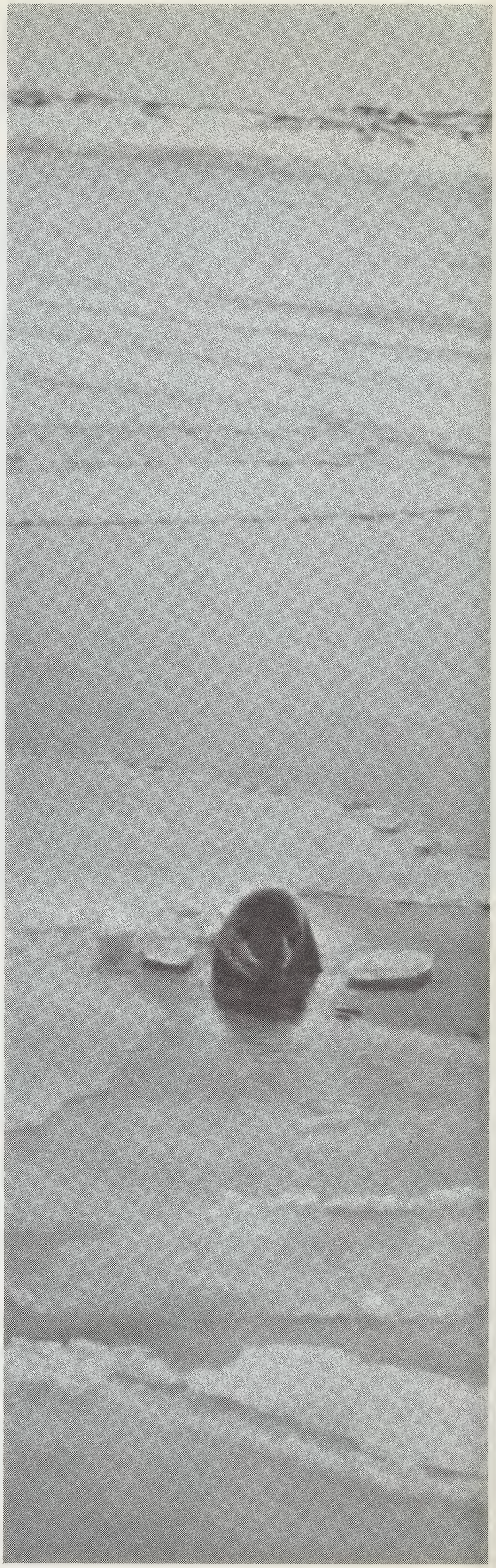
Two weeks later, while walking from the station to the penguin rookery under study, I spotted a leopard seal acting very strangely on the sea ice of a small bay. It was lying on its side, raising its right flipper and head with a moaning sigh. I ran back to the base to fetch a weapon more effective than the revolver. With a .303 rifle, I shot the seal from 50 yards. As I examined the dead seal I saw five wounds on its head. Was this the wounded seal from the revolver incident? Carefully, I dissected the head of the seal and found three copper jacketed bullets in the cerebrum.

During three Adelie penguin breeding seasons at Wilkes I rarely observed leopard seal predation on penguins. My general impression was that this seal was not a very significant threat to penguin survival in my study area and that the stories of leopard seals feeding on penguins might have been exaggerated. However, my experience on four additional trips to the Ross Sea sector of Antarctica changed my mind.

My indifference to leopard seals shifted to dislike quite suddenly. In late October 1962, I was walking on the sea ice off the shore of Cape Crozier, Ross Island, with Dr. John Emlen of the University of Wisconsin and Robert Wood of The Johns Hopkins University. I was trying to familiarize my companions with safe and unsafe sea ice. We were standing adjacent to an ice fissure formed by tidal movements and constant refreezing. Suddenly a huge head, reptilian in appearance, lunged through the fissure and a gaping jaw snapped at my leg, missing by a hair. We retreated to safer ice, contemplating what one would do if dragged by the leg into the 28.5° F. water by a hungry leopard seal.

During the austral summer of 1962-63, I had several opportunities to observe leopard seal predation on the approaches to Cape Crozier, where 300,000 Adelie penguins breed. Unfortunately I was busy conducting research on the way penguins navigate and there was little time to carry on consistent observations on the ecological significance of the predator-prey relationship between the leopard seal and penguin. I had to wait two years before my dislike for the beast was converted to respect.

Late in October 1964, again before the Adelie penguins had returned from their winter feeding grounds to Cape Crozier, I was walking alone along the shore ice-foot. The ice-foot consists of sea ice and pressure ice resting on the rocky shoreline. On this particular day the floating sea ice had moved



away from shore, leaving about 20 feet of clear water three feet below. It was a beautiful austral spring day. The water was clear blue, the snow-covered sea ice a glistening white, and I could see the bottom with the aid of my polaroid glasses.

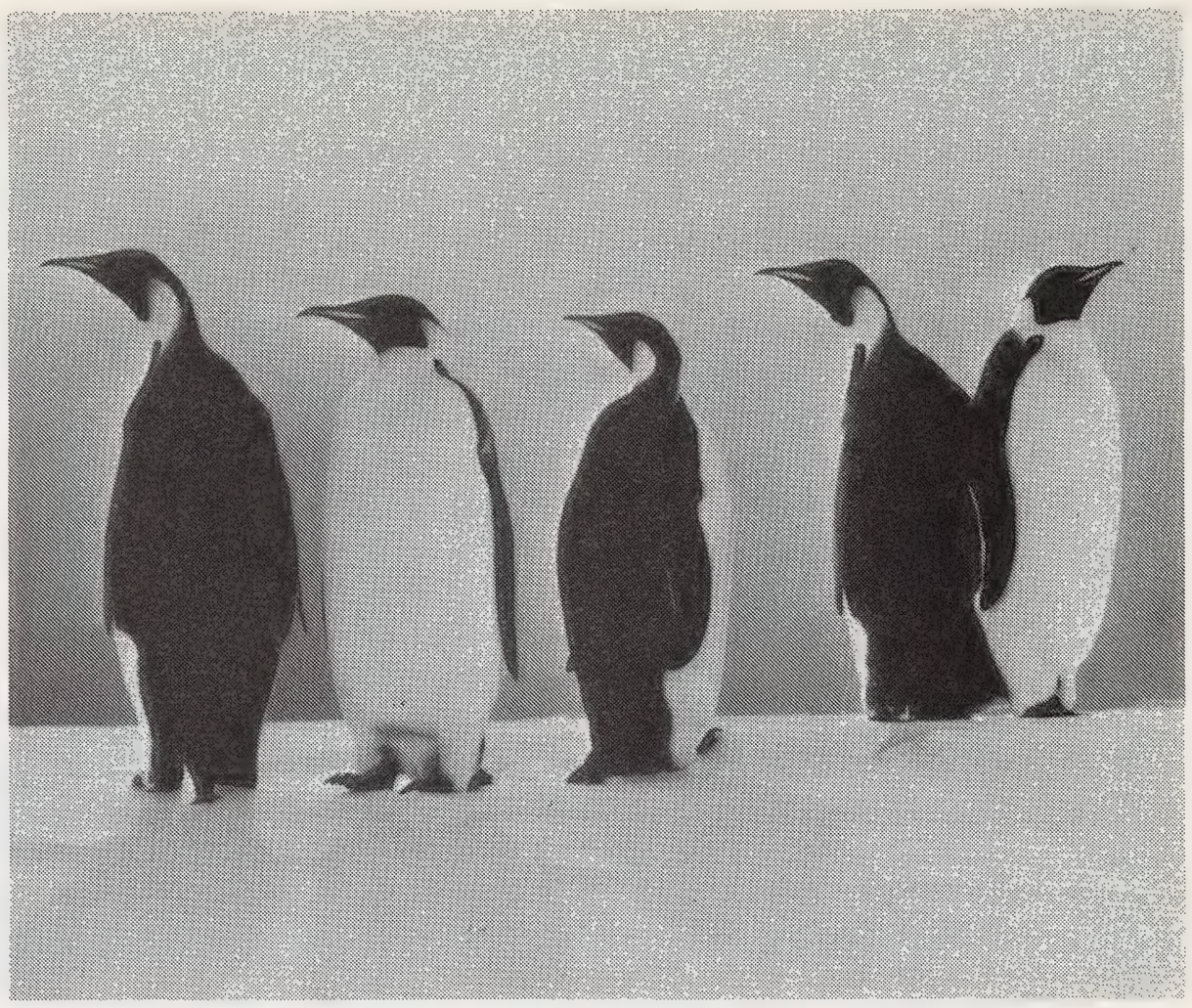
As I wandered along the edge of the ice-foot, I suddenly heard a peculiar sound of varying pitch coming from underwater along the edge. In an effort to attract whatever made the sound, I chipped off a piece of ice-foot with my heavy field knife and tossed it into the open water. Within a few seconds a leopard seal came along the ice edge. Slightly submerged, it lifted its head out of the water and looked toward me as it passed about six feet away. Presumably, when the ice splashed in the water, the seal suspected that a penguin had jumped into the sea.

I chipped off another piece of ice. The open water was as clear as crystal and without a single ripple. In went the ice and about 20 yards to the right, a leopard seal surfaced and with wide-open mouth swam swiftly toward me. It dove and then came up with a spectacular six-foot lunge out of the water – directly at me. Automatically I jumped back while extending my hand with the field knife to protect myself. The seal bit down on the blade and slipped back into the water, leaving a little flesh on the subzero knifeblade. I now had respect for leopard seals and vowed never again to walk along the ice foot before the penguins returned to the rookery.

Later in the same summer I found time to make some systematic observations on leopard seals. My partner in the study was George Lowry, a sheep farmer from New Zealand. He had come to Cape Crozier to assist in a penguin banding operation supervised by a group of biologists from The Johns Hopkins University. This project was designed to build up a large population of banded birds of known age for behavioral and ecological studies. Even though the penguin banding was our main task, watching leopard seals turned out to be the most exciting part of the summer.

Between January 21 and February 16, 1965, we carried out 64-3/4 hours of observations on leopard seal predation at Cape Crozier. In the 34 observation periods, 39 adult and young Adelie penguin kills (or 0.61 kills per hour) were observed in the study area. In the areas east and west of our study area, a rate of 0.46 kills per hour was noted.

The Adelie penguin seems particularly vulnerable to leopard seals in heavy seas, when landing at the rookery is hindered by intense surf. Full-grown young birds are particularly reluctant to enter the sea for the first time during heavy surf.

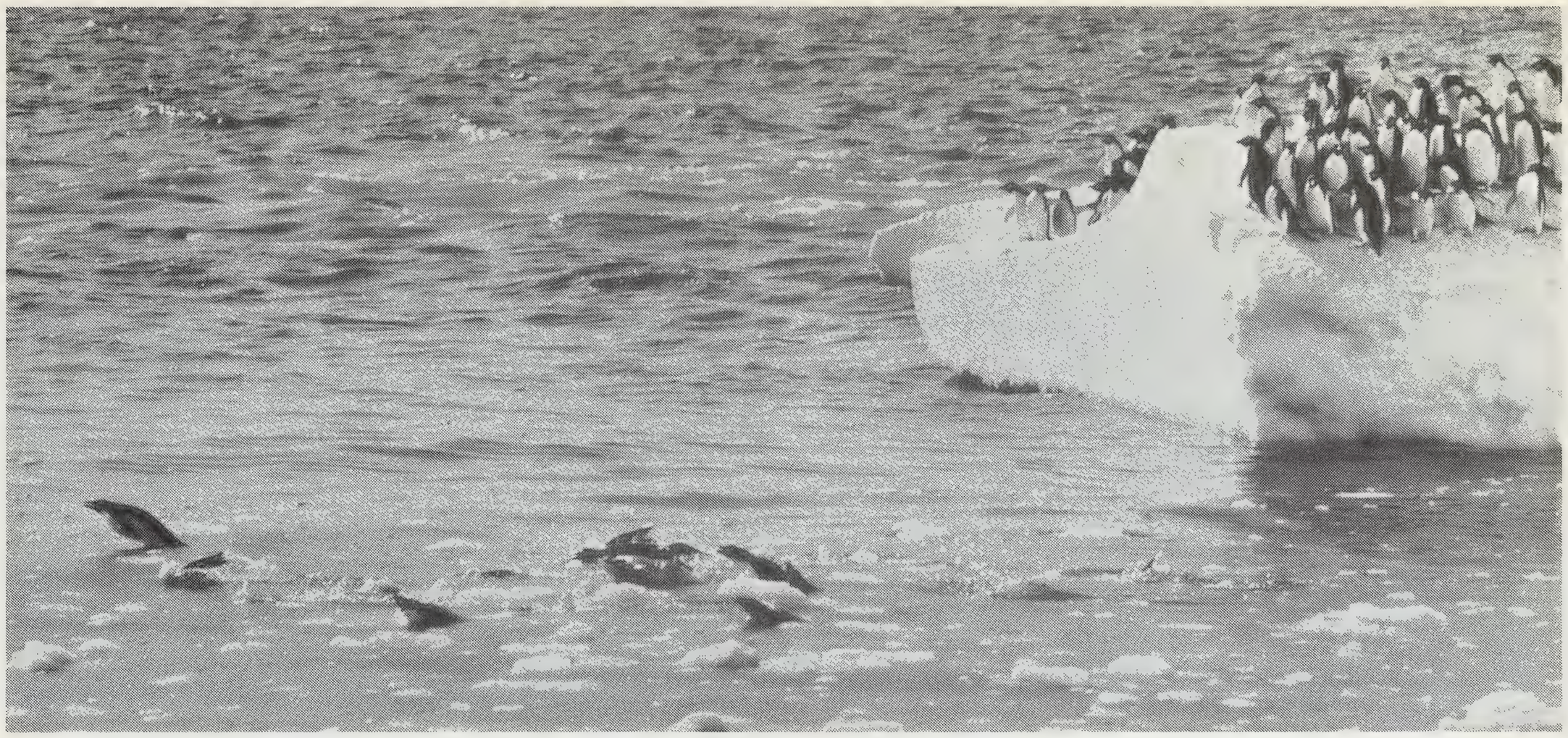


A leopard seal, opposite, breaks through the ice in pursuit of a penguin that escaped out of camera range. Above, emperor penguins, which are almost four feet tall and weigh 75 pounds, are the largest of the 17 penguin species.

Slush ice along the beach presents a particularly dangerous situation by impeding both swimming and walking. On January 23, 1966, on approximately 200 yards of beach, William Emison from Johns Hopkins found 32 dead or injured birds in a 24-hour period when there was 100 percent unstable ice along the beach area. Five birds were dead from ruptured stomachs due to ice crushing, 14 had broken legs, 11 had seal wounds on the neck, and two showed deep abdominal cuts from seal bites. During our own observations in the study area, 12 adults were found with serious injuries due to buffeting in the icy surf, but only two birds were found with obvious injuries from leopard seals.

On January 30, the young penguins in our area began to leave their rookery for the first time. From then on, leopard seals took only young birds, but the observed hourly kill rate was only half that previously recorded for adults. At this time of the breeding season, as parents and chicks separate, there is a great decrease in the adult traffic to and from the rookery. In addition, the time period during which the majority of chicks depart to sea is relatively short – about one week. After this the number of departing chicks declines rapidly.

While the behavior of leopard seals hunting penguins undoubtedly varies with differing ice conditions, the following generalizations can be made about the way the seals hunt in open water adjacent to the rookery beaches. When only adult penguins are moving through the area, the seals



A group of Adelie penguins on an ice floe prepare to jump into the sea while in the water below them, other Adelie penguins swim in that manner known as "porpoising."

often cruise along the beach at a speed estimated at six to seven knots, while riding the breaking point of incoming waves or the backbrush of waves in heavy seas. The seal's head is held high, facing seaward. If the seal is not cruising, the hind flippers are also visible above water with the back bowed and below the waterline. When porpoising penguins approach the beach and swim near the seal, it dives and grabs its prey under the water. The seal surfaces within 10 to 30 seconds, most frequently holding the prey by the head. The penguin is then tossed back and forth two or three times until blood is drawn or the bird is badly mauled. The seal then releases the penguin and starts to feed, with many tosses of the head and obvious biting movements, until only a relatively clean skeleton remains. The seal can consume a penguin in four to seven minutes. South polar skuas often flutter around the kill picking up bits of flesh, the head, and portions of skin. Giant petrels sometimes settle on the water and feed on the penguin remains as they drift away from the shoreline.

When the chicks begin their exodus from the rookery, there is a striking change of behavior on the part of the leopard seals. The seals now face the beach. They cruise along the shore at high speed less frequently. Young penguins moving into the water on their first trip to sea do not appear to be aware of danger from the seals. They do run back from the edges of ice floes when seals lunge up at them from the water. As large groups of adult penguins and chicks head into the water, the seal dives from a distance of up to 150 yards. The chicks are easy prey as they bob along on the surface of the sea and lag far behind the adults, which immediately out-distance them by swimming under water and porpoising. The seal stays submerged until, suddenly, it attacks a chick from below the surface, and then lunges out of the water.

On several occasions the leopard seals appeared to play with captured chicks by mouthing them lightly before killing them. One chick escaped after being caught and mouthed for several minutes. Twice we saw a seal lunge persistently at chicks on ice floes, once while carrying another chick in its mouth.

Leopard seals seem to be highly adaptable to a variety of situations. One seal in pursuit of an adult penguin atop the ice broke through three inches of fresh ice from below several times. The penguin finally escaped. Other seals waited below the shoreline ice-foots from which penguins dive into the water. Occasionally a seal actually followed ashore a penguin which had difficulty escaping from the backwash of a wave.

We never observed leopard seals hunting near each other. Once kills were made by two seals on either side of an ice floe approximately 30 yards in diameter. We doubt that these seals have territorial hunting areas along a given beach; they probably prefer the most advantageous water, surf, and ice conditions at a given time. One seal, which we named "Scarback," was seen working along the entire beaches of the West Cape Crozier Rookery. Our observations indicate that no more than four different leopard seals hunted in the area of our study.

The behavior of the Adelie penguin in relation

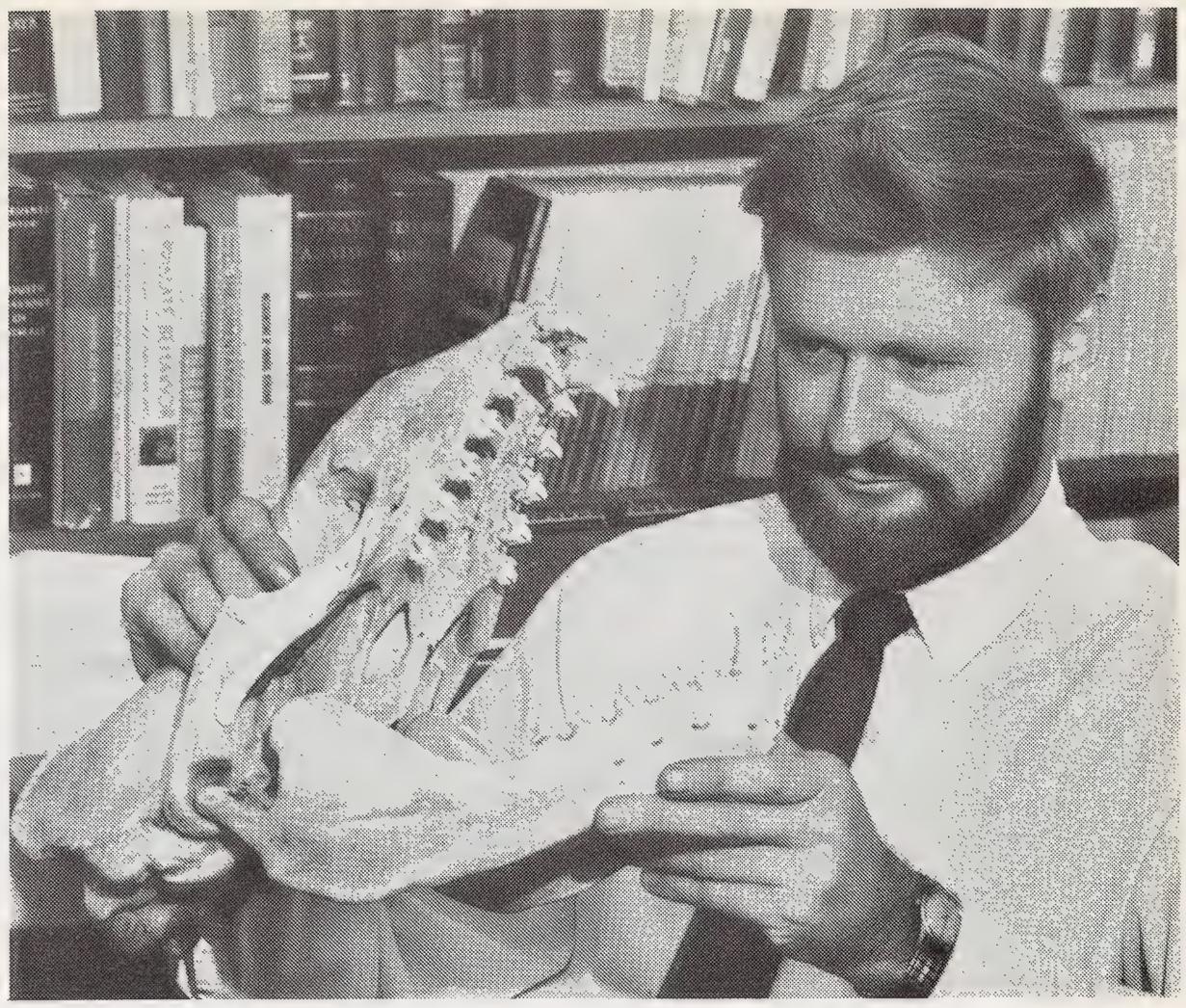
to the predator seems to follow several simple rules. While on the ice-foots or shorelines of the rookery beaches, adult Adelie penguins are hesitant to enter the water if a leopard seal is visible in the nearby surf. The penguins usually venture into the sea in large groups. In fact, many biologists have found it difficult to drive groups of Adelie penguins or even individuals into the water.

Penguins approaching the rookery from the sea, usually porpoising rapidly at about eight knots, do not appear to notice the leopard seals until they are very close. Occasionally groups of penguins suddenly change course, avoiding the area around a feeding seal. Many times, however, the incoming groups move straight up to a seal. Subantarctic penguins on the island of South Georgia are reported to outmaneuver leopard seals by swimming in short circles under the water. When a leopard seal is basking on an ice floe, it is not uncommon to see Adelie penguins standing within a few yards of the seal, whether it be sleeping or moving about on the ice surface.

Our short-term observations allow only a general assumption about the extent of leopard seal predation on penguins at Cape Crozier. It appears, however, that 19 adult penguins are killed each day in the 100 yards of study area. We estimate that there are 750 yards of landing beaches along the West Rookery at Cape Crozier. In a season which normally runs 15 weeks, from the latter part of October to the end of January, total adult mortality along the landing beaches would be about 15,000 birds or five percent of the estimated breeding population. Additional losses of eggs and chicks would result when partners of incubating or guarding birds are eliminated from the population. The effects of this mortality are difficult to assess.

Total mortality of young penguins leaving the rookery for the sea is more difficult to calculate but we estimate that about 860 chicks were killed by leopard seals as they departed our study rookery for the season. The major exodus of chicks seemed to take place within about seven days, and in years of relatively favorable environmental conditions, the total production of departing chicks is probably one chick per breeding pair of adults. Thus, loss of chicks due to leopard seals along the rookery beaches appears minor in relation to losses of eggs and small chicks due to blizzards and the predatory habits of the south polar skua.

After our study of leopard seals, my respect for them increased greatly. Truly, this is a splendid creature of the south polar sea and it plays an important part in the marine ecosystem. It is to be hoped that Antarctic researchers will one day be equipped with a good submersible vehicle which will allow underwater observation of leopard seal behavior. Through modern techniques in biotelemetry and Nimbus satellite tracking systems, we may someday be able to monitor the yearly movements of these seals in relation to their food sources.



Dr. Richard L. Penney, of the Institute of Research in Animal Behavior, displays the skull of a leopard seal with its impressive size and dentition.

My final encounter with a leopard seal convinced me that I am not the only human who looks like a good penguin dinner to the seal. Last November I accompanied a group of men from several zoological parks who were collecting emperor penguins at Cape Roget, 375 miles north of Cape Crozier. Joseph Iding, of the Milwaukee Zoo, and I took a walk toward the sea ice edge, where hundreds of emperors were standing about. On our way we came to a two-foot ice fissure. I thought nothing of it and calmly skipped across. Joe, just behind me, did the same when, moving much too fast for our taste, a leopard seal lunged up through the crack and snapped at Joe's trailing foot. The seal missed by inches but kept on coming. It literally chased us across the ice for 100 yards at such speed that we had to trot to keep away from it. I vowed that someday I would write down my experiences as a warning to other Antarctic field workers that this carnivore of the deep can be inadvertently dangerous to man because of the difficulty it has in distinguishing man from emperor penguins. But, come to think of it, what emperor penguin would be careless enough to stand by such an ice fissure.

nunbirds

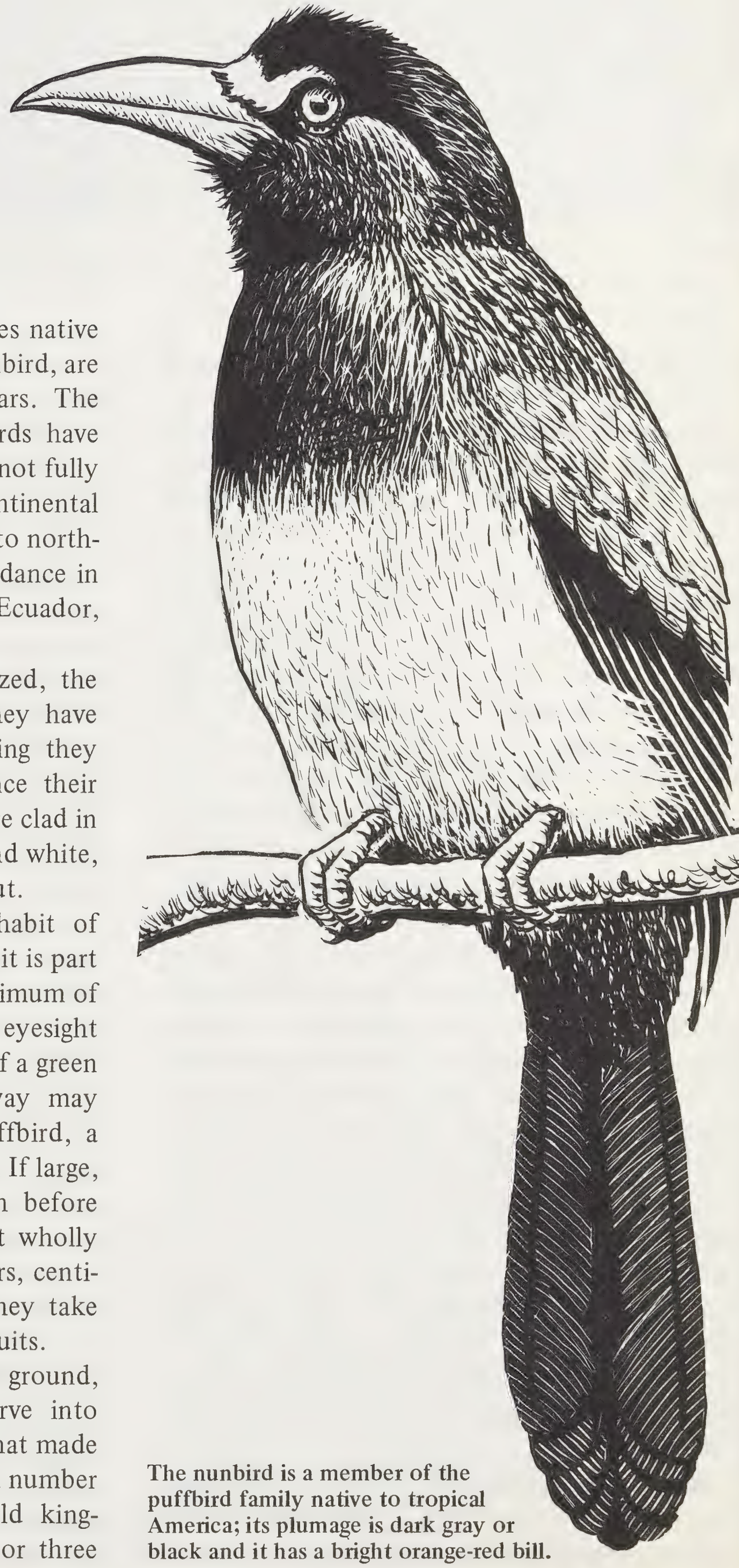
by Alexander F. Skutch

The puffbirds, a family of some 30 species native to tropical America and including the nunbird, are related to the woodpeckers and jacamars. The habits of less than a half-dozen puffbirds have been studied in detail, and even these are not fully understood. Puffbirds are confined to continental tropical America, from southern Mexico to northern Argentina, with their center of abundance in the Amazon basin of Brazil, Colombia, Ecuador, and Peru.

The smallest puffbirds are warbler-sized, the largest about as big as a blue jay. They have relatively large heads, and while perching they sometimes puff out their plumage, hence their name. Puffbirds lack brilliant colors and are clad in varying patterns of black, gray, brown, and white, and in some cases, bright rufous or chestnut.

The puffbirds are noted for their habit of perching motionless on branches. This habit is part of a pattern of foraging that entails a minimum of lost motion and wasted energy. Puffbird eyesight is exceedingly keen, and the movement of a green insect amid green foilage 20 yards away may release, in an apparently somnolent puffbird, a sudden swift dart that results in a capture. If large, the victim is pounded against a branch before being swallowed. Puffbirds subsist almost wholly upon insects, with an admixture of spiders, centipedes, and other invertebrates. Rarely they take small frogs and lizards. They seldom eat fruits.

Some puffbirds nest in burrows in the ground, others in cavities which both sexes carve into termitaries still inhabited by the insects that made them – a custom which they share with a number of jacamars, trogons, parrots, Old World kingfishers, and other birds. They lay two or three



The nunbird is a member of the puffbird family native to tropical America; its plumage is dark gray or black and it has a bright orange-red bill.

white eggs, which are incubated by both sexes.

Of the puffbirds whose habits are fairly well known, the most sociable are the nunbirds of the genus *Monasa.* These rather large puffbirds owe their English name to their plumage of deep gray or black. The bill of a nunbird is not so drab, being bright orange or red. The four species of nunbirds inhabit the heavier forests from Nicaragua to Bolivia and Brazil.

My first meeting with nunbirds was in 1940 on the Rio Yavari, which separates Brazil from Peru. Here the rubber survey party on which I served as botanist went ashore at a tiny settlement which someone with a longing for coldness and a sense of humor had called Islandia (Iceland). While we examined a young rubber tree growing in a plantation near the forest, a small flock of black-fronted nunbirds *(M. nigrifrons)* perched in the branches above us, uttering soft, musical murmurs while they twitched their tails from side to side. This brief encounter convinced me that nunbirds had unusual habits that would well repay study, but nearly 30 years were to pass before I could prove the correctness of my surmise.

Finally, in 1967, my long-standing desire to study nunbirds was realized in the Sarapiqui lowlands of northern Costa Rica, where the white-fronted nunbird *(M. morphoeus)* inhabits the tall, epiphyte-laden rain forests. The bird's deep gray and black plumage is relieved by short, stiff, outstanding white feathers on the forehead and chin, from the midst of which its orange-red bill springs. Its large, soft eyes are brown.

In early April 1967, Dr. Dennis Paulson, who was in the Sarapiqui region studying dragonflies, brought the good news that he had found a nunbird nest. He had seen three nunbirds with food in their bills fly across the swamp from the nearby cacao plantation and, following them, had discovered their burrow in a forested hillside.

It was then late in the afternoon, and we delayed visiting the nest until the rain that was falling the next morning had stopped. As we approached the nest site through the dim, dripping forest, we saw a large mound of freshly dug earth in front of a yawning hole. Some animal had utterly ruined our chance to examine what was apparently the first nest of the white-fronted nunbird ever to be found by a naturalist. For the next two months, we searched fruitlessly for another nunbird nest.

Early in the following April, an assistant and I discovered three occupied burrows. All were in heavy forest, amid the undergrowth of low palms, ferns, shrubs, and woody vines. From the opening in a moderate slope or nearly level ground, the tunnels descended into the earth with a slight inclination. The shortest tunnel was only 40 inches long and so straight that, with the aid of a flashlight, we could see right to the end. The other two were 55 inches long and slightly curved, so that it was not possible to see the far end and learn exactly what the tunnels contained. A thorough examination of the long burrows would have required excavation, which would have jeopardized our studies.

Around the mouth of each burrow the nunbirds had placed a collar of dead leaves, sticks, and other trash. This collar was thickest at the burrow in the most level ground, where it helped to conceal the elongated opening of the tunnel.

Soon after discovery each of our three burrows held nestlings. In the shortest burrow there were three young birds still blind and quite naked, with no down on their pink skin. They rested on a bed of brown, fragmented dead leaves, which lined the enlarged chamber at the far end of the burrow. With admirable devotion, the parent who brooded the young stuck to its post while we looked in with a flashlight, made notes, and even inserted a ruler to measure the length of the tunnel.

We were led to the discovery of these burrows by hearing the rippling, trilling, or purring call by which the nestlings' attendants announce their arrival with food. Often they repeat the call for two or three minutes, and much longer if they are distrustful, before they descend to the burrow's mouth. Searching for the inconspicuous burrow openings during incubation, when the parents probably sit still for hours at a stretch, is like looking for the proverbial needle in a haystack. Although I have watched several kinds of puffbirds excavate their nest chambers in termitaries, how and when the ground-nesting species prepare their burrows remain a mystery. Perhaps, like certain motmots, they dig them half a year before they lay their eggs in them.

In striking contrast to the excessive wariness shown by many tropical forest birds while attending their nests, the nunbirds were amazingly fearless in our presence. Although there were considerable individual differences, some birds would descend to the burrow's mouth while we stood, unconcealed, only five to ten yards away.

Feeding of the nestlings was a most interesting performance. Each adult brought no more than a single item of food at a time, usually an insect (often a cicada). The bird held the prey in the tip of its orange-red bill. After repeating the undulatory approach call a variable number of times, the

The white-fronted nunbird inhabits the tall epiphyte-laden rain forest of the Sarapiqui lowlands of northern Costa Rica.

The mouth of the nunbirds' burrow is surrounded by a collar of dead leaves and sticks to conceal the opening of the tunnel.

adult flew to the burrow's mouth and stood there on the ground, silently waiting for a nestling to come and take the food. If a nestling did not soon appear, the adult began to call, the notes growing louder the longer it had to wait, until they became a sharp *click click click* . . .

Only if it intended to brood, which was seldom, did a parent carry food inside the burrow. Even the youngest nestlings that we found, at most a few days old, took their meals at the doorway. Looking past the adult standing in front of the opening, we could see the little pink nestling come toddling down the tunnel, bobbing its sightless head and waving its rudimentary wings. After seizing the prey, it backed out of sight into the darkness of the burrow. In the longer burrows, the round trip between the chamber and the doorway was eight or nine feet.

This method of taking meals, which is practiced also by white-whiskered puffbirds, continued as long as the young remained in the burrow. Older nestlings, when very hungry, sometimes called *tuwee tuwee* as they approached the adult that offered the meal. Two nestlings rarely came simultaneously for food. It was even more rare to see two adults together at the burrow's mouth. After each adult delivered the meal, it promptly flew into the trees.

At each of the three nests we studied, three or four adults brought food. Apparently one, two, or more non-breeding birds assist in the parental offices. The helpers are probably yearlings who would not mature sexually until a subsequent breeding season. In many instances, no doubt, the extra birds were older brothers and sisters of the nestlings they attended. Such yearling helpers are known to occur in certain species of wrens, jays, and other families. At one burrow three attendants could be distinguished individually by broken or frayed tail feathers. However, we very frequently had three food-bearing adults in view at the same time, and occasionally four came in such close succession that we were fairly certain that none had repeated. About the time nesting began, one

member of a family group, doubtless the laying female, was liberally fed by several companions.

The three nestlings in the only burrow where we could see the whole brood at once were the same age and seemed to be the offspring of one female. Accordingly, we dismissed the idea that the nunbirds nested communally with several females laying their eggs together.

In contrast to certain other puffbirds, whose weak voices are seldom noticed, nunbirds have such a variety of calls that, whenever in the forests of Sarapiqui I heard a loud, unfamiliar bird note, I was inclined to attribute it to them. Often I proved to be right. Loudest and most surprising of their vocal performances is the chorus, which we heard from late March into June, but most frequently from mid-April to late May. Then the family groups attend more mature nestlings or fledglings already on the wing.

To deliver a chorus, the three or four adults of a family, or sometimes as many as eight or ten grown birds, would gather in a compact group well up in the forest, more rarely in a tree in an adjoining clearing. They would perch a few inches apart, often in a row on a slender horizontal branch or a vine stretched between two trees. The dusky participants would tilt their heads upward and cry together in loud, ringing, almost soprano tones, with so much gusto that their whole bodies shook. The chorus swelled or waned, as birds joined in or stopped singing, but for 15 or 20 minutes there would be only brief intervals of silence.

No other bird that I know performs in a similar manner. We heard these unique choruses chiefly around midday. The function of these social exercises is not clear, but they seem to strengthen the bond between the several members of a family group, much as in many species of tropical birds duetting or antiphonal singing helps to bind together the members of a constantly-mated pair.

Once a chorister held an insect in its bill. At the conclusion of the performance it flew off toward a nearby nest, followed in single file by the three other attendants of the nestlings – an impressive sight. At times, when eight or more nunbirds perform together, the chorus may help to define their territorial boundaries, or it may be just a friendly gathering of neighbors. I never saw a nunbird display hostility.

Unlike nestling jacamars, which often sing in their burrows, the young nunbirds remained quietly out of sight in their subterranean nursery, and we rarely heard or saw them except momentarily, when one came to the entrance for a meal.

Once, however, I happened to be looking into the shortest burrow when an attendant alighted close behind me, giving the approach call. Although nestlings do not ordinarily respond to this call, on this occasion they must have been very hungry, for they started to run up the tunnel toward the doorway, and I easily caught the one which arrived there first. Its plumage was just expanding. I noticed that its heel joints were coverd by callose pads, which were smooth rather than spiked as in nestlings that grow up in holes in trees and termitaries. These pads protect the heels, which bear much of the nestling's weight, from abrasion against the unlined or poorly-lined floor of the brood chamber. When I replaced the young nunbird, it promptly ran down to join its siblings at the inner end of the burrow.

A few days later, this short burrow was dug out by some powerful animal, possibly a tayra. While I stood contemplating the melancholy spectacle of the ruined nest, the four attendants arrived with food in their bills. One by one, they stood on the mound of freshly dug earth in front of the pit where their burrow had been and called the lost nestlings. Low at first, their notes rose to almost frenetic intensity as they were repeated over and over without a response. For at least 24 hours after the nestlings were taken, some of the attendants brought food for them.

In a longer burrow, the nestlings remained for about a month. Emerging from their subterranean abode, they promptly rose high into the great forest trees, where it was difficult to see them. Their bills were pale rather than orange-red, their foreheads and chins orange-buffy instead of white, and their body plumage darker than that of adults.

After the juveniles were older and could fly well, their parents sometimes led them into the shade trees of the cacao plantations and other clearings,where we could watch them being fed. After catching an insect or some other small creature, and perhaps beating it against a branch, the adult would not pass it to a juvenile, as many birds do. On the contrary, the attendant continued to perch, holding the food conspicuously, while the youngster flew up, and without alighting snatched the article from the adult's bill. Birds with such well-controlled flight seemed quite capable of foraging for themselves, but perhaps they still had difficulty recognizing appropriate food. This spectacular method of taking their meals provides excellent practice in the mode of foraging typical of puffbirds, which combines motionless perching, sharp-eyed scrutiny, and sudden bursts of highly effective activity.

NARWHAL

Photographs of an Expedition

When the call went out in September from the Canadian village of Griese Fjord that Eskimos had captured a narwhal calf after killing the youngster's mother, the New York Aquarium sent a rescue team headed by Curator Robert Morris (right) and Veterinarian Jay Hyman (left).

A pod of narwhals, the lengendary unicorns of the sea, are seen surging through the waters off Ellesmere Island in Canada's Northwest Territory. The spiraled tusk, which develops, with extremely rare exceptions, only in the male, is really the elongated left canine tooth of the animal.

Part of the aquarium team's task was to determine whether an adult narwhal could be collected at some later date. For this purpose, nets were rigged (see photograph at left) and tested at sea in an eskimo canoe (above).

NARWHAL

The village of Griese Fjord, on the southeastern tip of Ellesmere Island, is the northernmost community in Canada's Northwest Territory. This area, above the Arctic Circle, is one of rugged and stark beauty.

The young male narwhal, named "Umiak" after the Eskimo word for canoe, received medical attention from Dr. Hyman on the shore of the pond where he had been kept by the Eskimos. The chances of the youngster's survival in the wild were slim, with the freezing northern weather moving in quickly.

After a flight of 2,650 miles, Umiak arrived at the New York Aquarium in Coney Island and was carefully lowered into the whale tank. The tank, home to the aquarium's four belugas, or white whales, was divided into two sections by a fence to make room for the youngster.

NARWHAL

Upon arrival, Umiak was about two months old, measured six feet in length, and weighed an estimated 200 pounds.

The belugas, close relatives of the narwhal, looked on as Animal Keeper Peter Fenimore "walked" Umiak around the tank to loosen up the young animal after the long trip.

The first narwhal ever exhibited in a public aquarium, Umiak was the center of attention for the aquarium staff and visiting scientists, whose observations on behavioral information will help in the maintenance of the species in the future. Unfortunately Umiak succumbed to pneumonia and died on October 7, 1969.

The Deceiving Sea Anemone

An animal that looks like a flower

by U. Erich Friese

Tentacles and oval disc of the beaded sea anemone, *Tealia covicae.*

The sea anemone is an animal whose looks truly are deceiving. With its graceful tentacles waving like delicate petals in the water and its brightly-colored stem, the sea anemone resembles a flower, and a marvelous one at that. Nevertheless, the sea anemone is a bonafide member of the animal kingdom, although relatively low on the scale of evolutionary development.

Sea anemones belong to the phylum *Coelenterata,* a group of animals characterized by an uncomplicated body structure. A simple cellular tissue layer, the epidermis, covers the body, and another layer, the gastrodermis, lines a larger, sometimes branched, body cavity. A jelly-like and mostly structureless substance (mesoglea) between the two tissue layers forms the bulk of the body. The *stomodeum,* a tube-like connection between the main body cavity and the mouth opening, simultaneously takes in food and gets rid of undigested matter. In addition to the sea anemones, the coelenterates also include jellyfish, coral polyps, and the comb jellies.

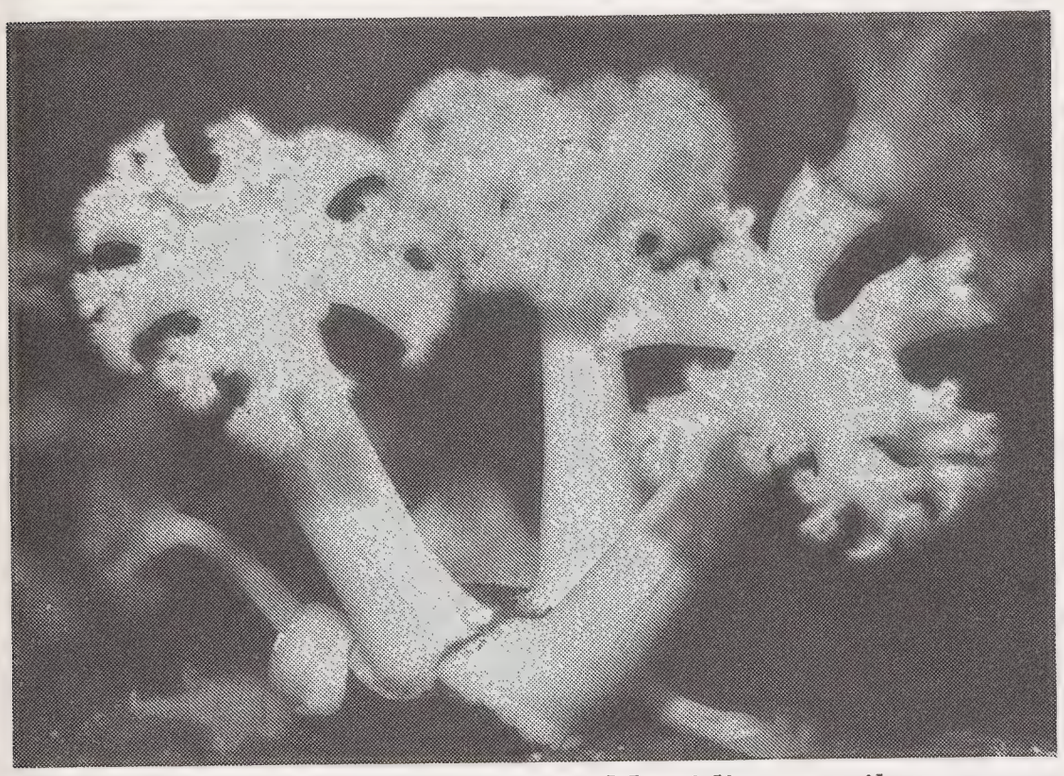
In fact, one could compare a sea anemone to an upside-down jellyfish that is anchored in place. Depending upon the species, the cylindrical body of a sea anemone may either be squat or slender and elongated. Invariably, sea anemones are brightly colored, ranging from snow white, through greyish brown and red, to vivid green and blue. Many species are even multicolored. One or more rings of delicately shaped tentacles, which are usually equipped with many small stinging cells, surround the mouth opening. At the other end of the body most sea anemones have a flat fasal or foot plate with which they attach themselves tightly to solid surfaces.

There are about 1,000 species of sea anemones which range in size from a half-inch to five feet in diameter. Sea anemones are found in all the oceans, and they range vertically from the intertidal zone down to 30,000 feet. Such an extended and variable environment requires, of course, considerable adaptation. Nowhere can this be better seen than in the diversified fauna of Puget Sound, along the margin of the northeastern Pacific Ocean. There, in 50° F. water, I have observed and collected a number of sea anemone species, each in a very distinctly different habitat. More than once I risked life and limb climbing over the treacherously slick rocks and boulders of the unprotected ocean shore around Cape Flattery, searching for the giant green sea anemone,

Anthopleura xanthogrammica **with footplate attached against the aquarium glass.**

Anthopleura xanthogrammica. Tightly secured against the solid rock and partially hidden in cracks and crevices, this species endures the continuous pounding of the Pacific Ocean surf as it rolls into the Juan de Fuca Strait.

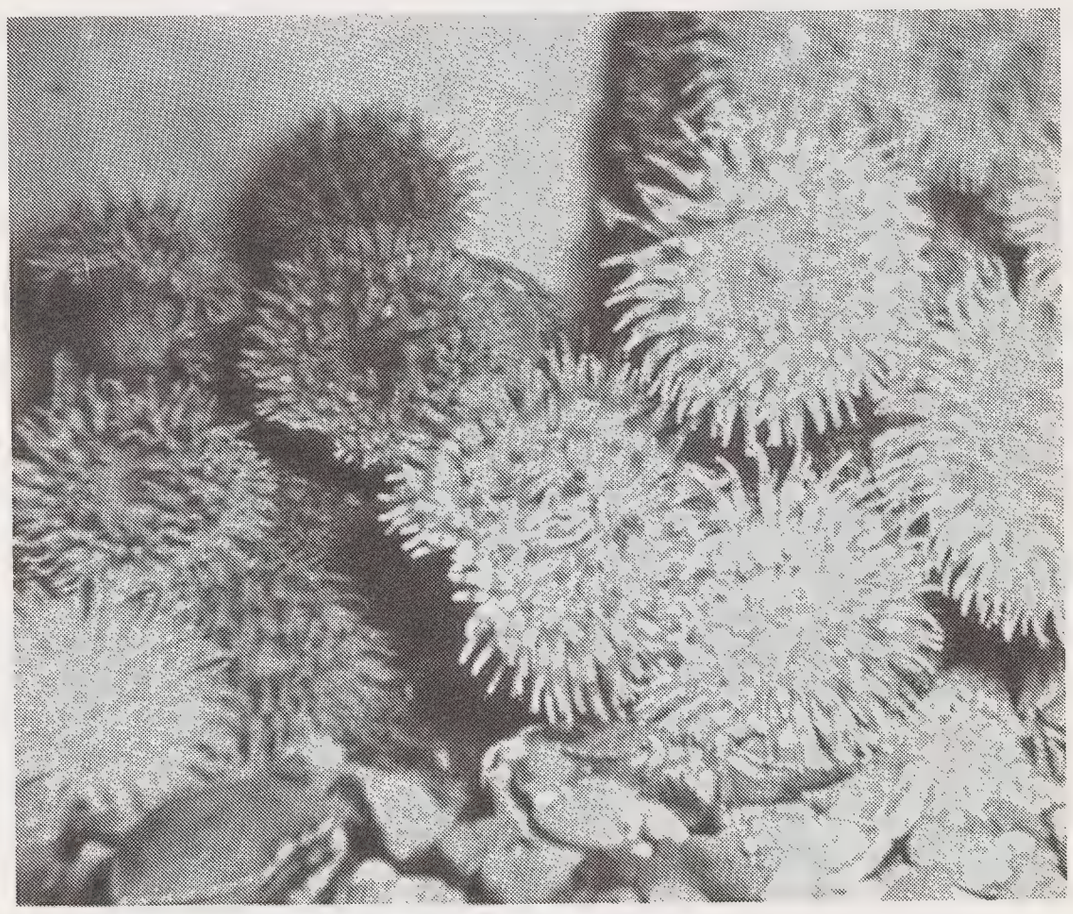
Completely different is the habitat of the white-plumed sea anemone, *Metridium senile.* Because of the extreme tides of the Pacific Ocean,



The white plumed sea anemone, *Metridium senile.*

this anemone has to endure extended periods out of the water during the low tides. Along the Seattle waterfront, on the wooden pilings of the aging piers, thousands of these anemones hang limply above the receding water line. But somehow they always seem to survive until the return of the high tide a few hours later. The small rough sea anemone, *Anthopleura elegantissima,* lives on low-lying beaches north of Seattle, along the main channel of Puget Sound. The considerable freshwater runoff in this area seems to be very well tolerated by the creature. Other species, like the beaded sea anemone, *Tealia,* may even live permanently in brackish water.

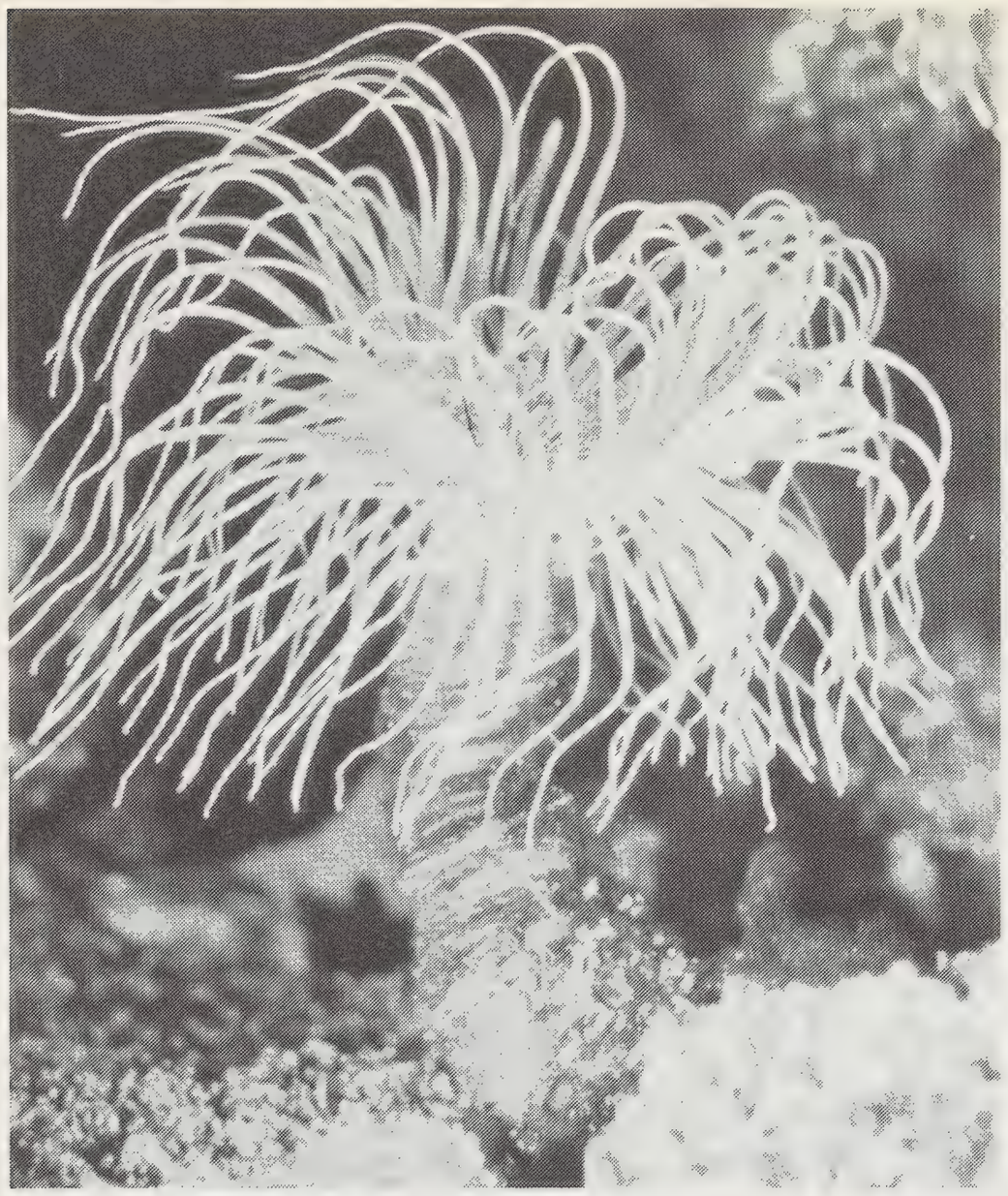
While most sea anemones remain solidly attached to a firm substrate, such as rocks, pilings, sea shells, and sea weed, some species live semiburied up to their tentacles in muddy bottom. The latter use small stones or mud clumps for ballast. These burying sea anemones do not have the usual flat foot plate. Instead, their bodies terminate conically, permitting these animals to dig into the mud. Members of the genus *Cerianthus* build parchment-like tubes around their bodies, which are then partly submerged into soft sand. Some other sea anemones have taken up a strange planktonic existence; they drift aimlessly at the sea surface, their mouths pointing downward. The basal plate in these animals is concave – similar to the bottom of a wine bottle. The edges of the



Beaded sea anemone, *Tealia coricae.*

cavity are tightly closed. The chamber so formed contains a mixture of gas and a spongy substance which give the animal buoyancy.

As defenseless as sea anemones may appear, they have a variety of protective mechanisms at their disposal. If disturbed, the sessile species will immediately contract by expelling most of the water from their gastric pouches, thus reducing their surface area considerably. In addition, they will also slowly invert the entire oral disc, tentacles included, into the gastric cavity. A special muscle arrangement will then completely close off the remaining opening. This will also occur when an intertidal anemone becomes emerged during low tide. The animal must then retain sufficient body moisture until the next high tide submerges it again. The burying species of sea anemones will immediately withdraw into the subtrate when they are disturbed.



A sea anemone of the *Cerianthus* species.

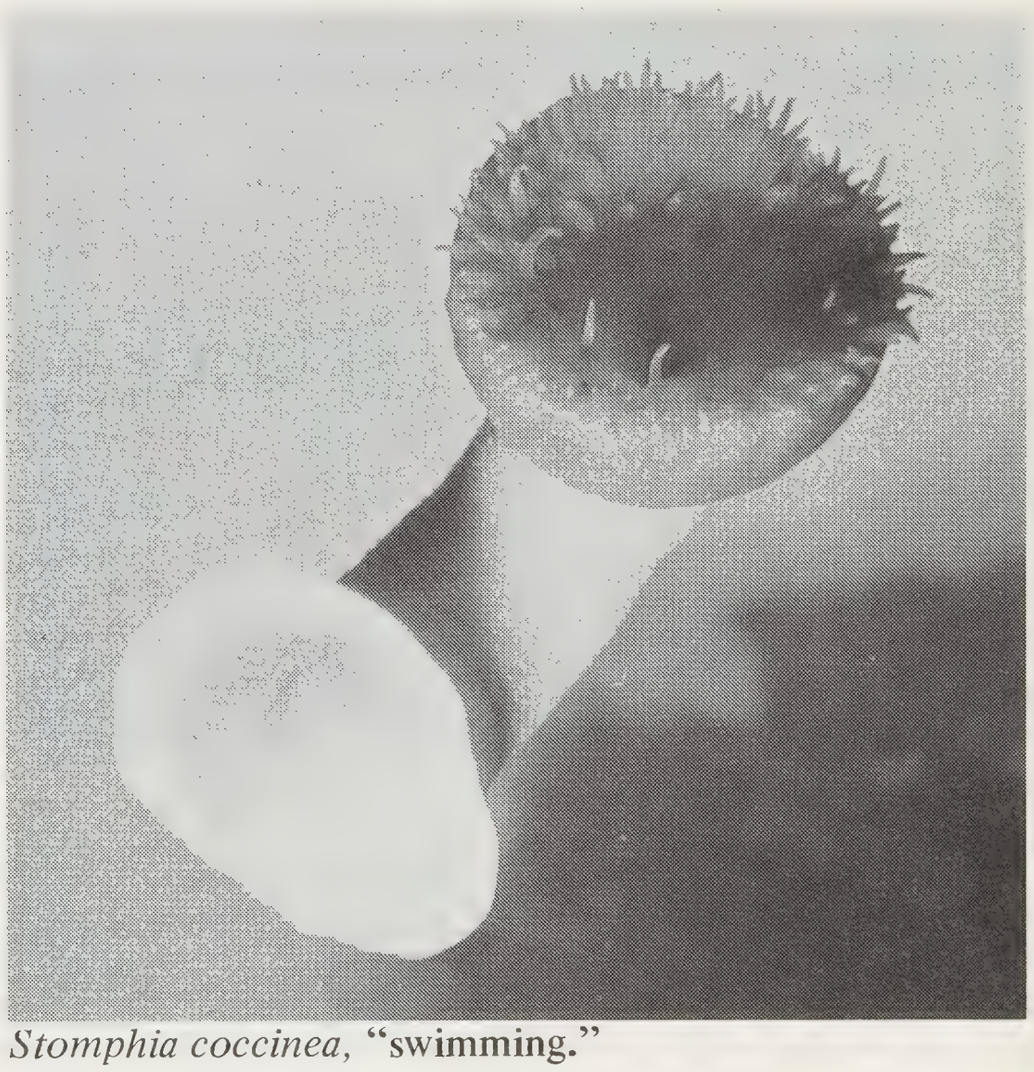
The only anemones ever observed escaping from a potential enemy are *Stomphia* and *Actinostola.* I vividly remember my first encounter with this phenomenon during one of my college zoology courses. The professor had some *Stomphia* specimens in one tank, and he would add a leather starfish, *Dermasterias imbricata,* from another tank placing it close to the anemone. The sea anemone would suddenly become erect and detach itself from the substrate. Then, with a series of rapidly alternating contractions and expansions of opposing muscle bands, the sea anemone actually swam away from the starfish. This unique reaction is species specific and can be induced merely by adding some skin extract from a predator to the water in which the sea anemone lives.

An active defense mechanism exists in all sea anemones in the form of tiny stinging cells, located in great numbers along the tentacles and on the oral disc of the animals. These cells in some species may be able to penetrate human skin, and thus a stinging feeling sometimes results from touching an anemone. When a small fish accidentally comes into contact with the stinging cells, it will be immediately paralyzed, and the tentacles will then slowly manipulate the prey into the anemone's mouth.

Most sea anemones have the ability to move their tentacles spontaneously. In fact, they are able to move the entire body very slowly and thus may change position by alternating contractions and expansions of opposing muscle bands. This causes wave-like motions of the foot plate, which may move *Metridium* about one-half inch per hour and *Sagartia davisi* about one inch per hour. *Actinia equina* is a relative speed demon, racing about at three inches per hour and accomplishing a daily grand total of about two feet! Other species may crawl along the bottom by alternately attaching and detaching tentacles and foot plate. Active swimming motions by means of the tentacles beating in the water have been observed in *Conactinia prolifera* and very young specimens of *Stoichactis.* Both species can travel more than a half mile per day.

A number of sea anemone species hitch rides by attaching themselves to other animals. New York Aquarium collectors in the Virgin Islands found recently a lovely pink-tipped sea anemone, *Condylactus passiflora,* solidly attached to a flame shell, *Limia scabra.* Other sea anemone species are often seen on the carapaces of slow-moving crabs.

Sea anemones respond almost instantaneously to a variety of mechanical, chemical, and optical stimuli. Very small concentrations of liquid extracted from mussles will cause *Metridium* to point its oral disc toward the food source and open its mouth. *Actinia equina* will accept small pieces of paper that have been soaked in certain water-soluble amino acids. As mentioned earlier, *Stomphia* reacts dramatically if in contact with tissue



Stomphia coccinea, "swimming."

extracts from its enemies. Other sea anemones actively seek light or shaded anchorages. Some open their crown of tentacles only during the day. Others open up only at night.

While some species exhibit distinct day versus night responses, others may display behavior in

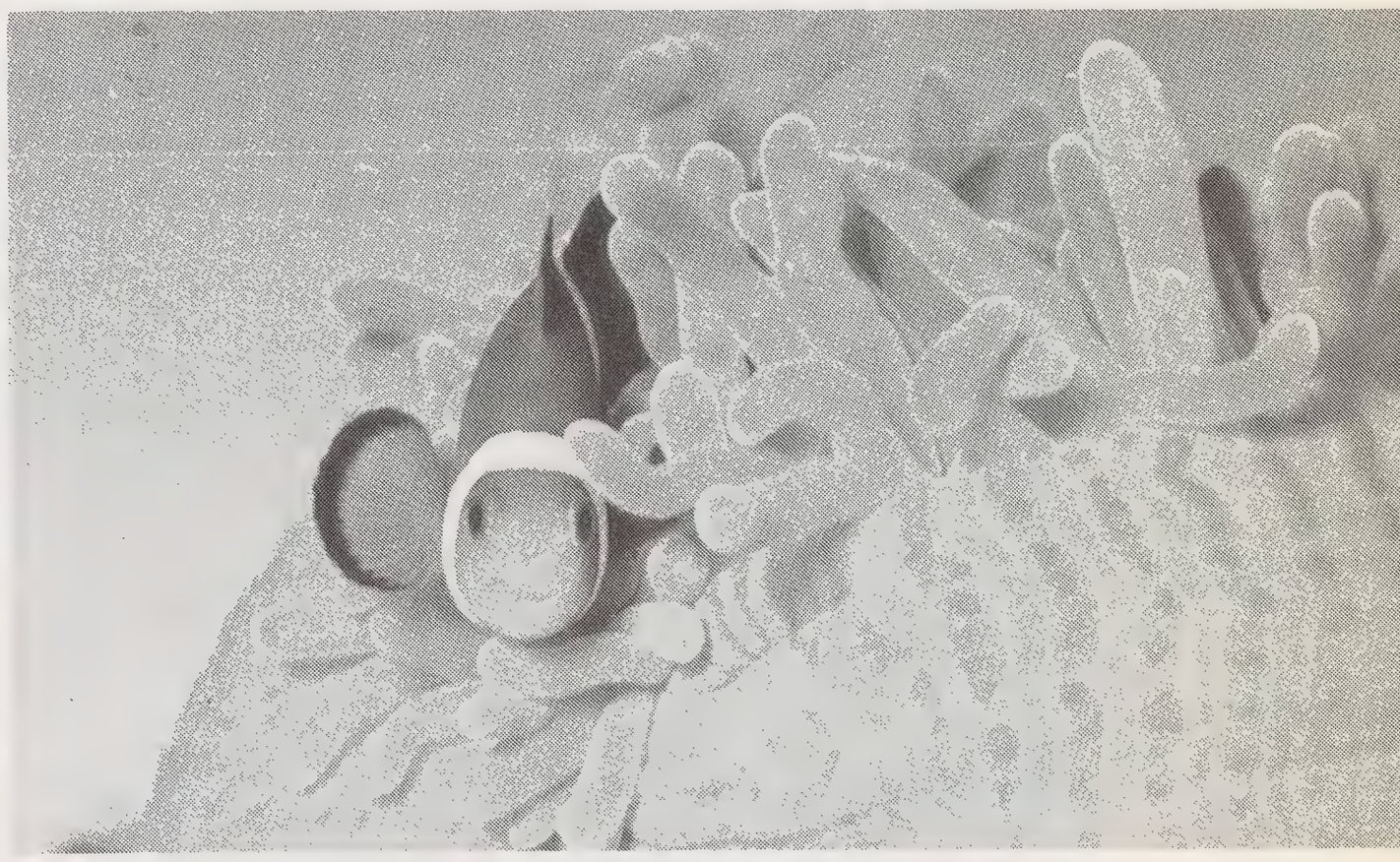
correlation with the tidal fluctuations of their habitat. For instance, if one puts *Actinia equina* – a typical inhabitant of the intertidal zone – into an aquarium, regular contractions and expansions of the body will be observed in coordination with the actual tidal rhythm of the environment from which the animal had originally been removed.

Sea anemones fall into two basic feeding categories. The **predators**, such as the large *Tealia columbianae,* have strong tentacles equipped with particularly powerful stinging cells; they are able to paralyze their prey instantly. These species feed predominately on small fishes, some shrimps, crabs, and other invertebrates. The **particle feeders** feed with the aid of cilia (tiny hair-like projections) on their tentacles and oral disc *(Metridium, Halcampa, Sagartia).* Minute floating organisms will stick to the adhesive cilia, which will then transport the food by uniform, directional beating toward and into the mouth of the sea anemone.

Reproduction of sea anemones is either sexual or asexual. During sexual reproduction the male releases the spermatozoa into the water through the oral opening, from the tips of the tentacles, or from the pores of the body. This invariably stimulates the female to release her eggs into the water, where they are then fertilized by the free-floating spermatozoa and where the development of the minute baby sea anemones takes place. Variations exist between species. In some, the female closest to the male will actually bend toward the male; in others the female will move toward the male to enhance fertilization of the eggs. Latitudinal variations may also occur within the same species. The female *Tealia felina* will incubate the eggs in arctic waters, while the very same species in the North Sea is strictly oviparous, releasing the eggs into the water for fertilization.

Asexual reproduction consists usually of longitudinal separation. A longitudinal furrow develops vertical to the animal's plan of symmetry. The furrow eventually splits the entire animal into two new, but smaller, sea anemones, In some species the parent animal sheds small pieces of its tissue, from which tiny anemones develop.

One of the most interesting aspects of sea anemone behavior is the close relationships formed with other animals of the sea. A particularly well-defined symbiosis (the living together of two dissimilar organisms in close association for mutual benefit) exists between sea anemones and many hermit crab species. The hermit crab *Pagurus arrosor* will actually encourage and help the sea anemone *Calliactis parasitica* to move onto the crab's shell. There appears to be a rather close tie between the two animals. An even closer relationship has been observed between the hermit crab *Eupagurus prideauxi* and the sea anemone *Adamsia palliata.* The latter has never been found without its host. In fact, *Adamsia* is responsible for the growth of the shell of the hermit crab. A secretion given off by the sea anemone gradually enlarges the shell, and thus the crab never has to leave its "home." One expects that such relationships have developed to the benefit of both animals. The hermit crab receives added protection from the anemone's powerful stinging cells, and the anemone has more opportunities to come into contact with food while being carried around by the hermit crab.



A clownfish, *Amphiprion percula,* swims among the tentacles of a "host" sea anemone.

The large anemones, such as *Stoichactis* and related species, have intricate symbiotic relationships with certain fishes. Especially the genera *Premnas* and *Amphiprion* depend heavily on those host anemones for survival. These fishes live almost continuously among the tentacles of the sea anemones, or rarely venture far from them. In fact, spawning of *Premnas* often takes place right inside the large tentacular crown of *Stoichactis.* In return for this protection, the sea anemones receive left-over food from the fish. Some of the fish have even been observed actually feeding the host anemone. Certain relationships between anemones and fishes are not only species specific, but they may be also governed by the size of the anemone and the size of the fish. For instance, an anemone of a certain diameter will only accommodate a fish of a certain size. Larger fishes will be attacked and eaten by the anemone.

This sort of behavior makes the sea anemone an intriguing animal – even more so because it does not look like one.

Insect Travelers

Some butterflies migrate for thousands of miles

by Edward Edelson

Every October, monarch butterflies by the hundreds of thousands flutter into Pacific Grove, California, to spend the winter. Pacific Grove, which calls itself "Butterfly Town, U.S.A." and has an ordinance forbidding interference with the butterflies, is just one of the locations along the California coast and down into Mexico that welcomes the annual visit. In the spring the butterflies will be off again, some flying as far north as Canada to spend the summer months.

The migration of the monarchs is one of the most astonishing and least-understood phenomena in nature. Some of these creatures, seemingly so frail, fly well over 1,000 miles, and millions of them take part in the migration. Yet scientists do not know why the monarchs migrate, what guides them across such immense distances, or why the butterflies come back to the same locality – and even the same trees – year after year.

Uncertainty about the migration of other butterflies and moths is even more pronounced. Entomologists know, however, that a surprising number of insects migrate. Records of insect migrations go back to biblical days; the plague of locusts in Egypt can be reasonably explained as a migratory movement of the kind that still occurs. In more recent times, convincing reports have added many other insects – dragonflies, beetles, some flies, and wasps – to the list of migrators. Yet there is a significant lack of convincing explanations that fit the facts.

Perhaps more is known about the monarch butterfly than any other migrating butterfly. The monarch, whose scientific name is *Danaus plexippus,* is a native of North America that keeps

A group of monarch butterflies rests on a tree during migration. These insects usually fly in groups of two or three, gathering in numbers only to roost for the night. The migration of the monarchs is one of the most astonishing and least-understood phenomena in nature.

Semingly so frail, the monarch butterfly, *Danaus plexippus,* may fly over 1,000 miles. On each hind wing patch of the male monarch is a pocket containing scent-scales. Some scientist theorize that males lay "scent trails" through the sky to establish the migratory route.

popping up in other parts of the world – England, France, New Zealand, and Australia, among other places.

In North America, the monarch is a commonplace sight, with its rust-colored wings, trimmed in black. But the annual migration takes place in two distinct sections of the continent divided by the Rocky Mountains. Monarchs from the eastern United States and eastern Canada winter in Florida, the Caribbean islands, and Mexico, while those from the Pacific coast move to southern California, Baja California, and western Mexico.

The life cycle of the monarch starts when a female lays her eggs on the underside of the leaves of milkweed plants – the insect's only food. The eggs – a female can lay more than 400 – hatch out in three to 12 days, depending on the temperature. The larva that crawls out of the shell

is putty-colored, with a round black head. It measures only two millimeters long when it hatches, but over the next two weeks it grows at a furious rate. Chomping on milkweed leaves and shedding its skin four times, the larva is a two-inch-long caterpillar when it enters the next stage of its life.

Choosing a likely leaf, the caterpillar attaches itself with its own silk thread, sheds its skin for the last time, and forms a waxy green envelope that protects the pupa within during the critical time of change ahead. Over the following two weeks, the adult butterfly takes shape within the waxy chrysalis. When it emerges, the monarch spends a short time drying its wings and then flies away.

Usually, the newly hatched butterfly will join the migration almost immediately. In this, the butterflies are following ages-old instincts – the female who laid her eggs a few weeks before may be a thousand miles away by the time the new generation begins its flight.

The monarch is capable of almost incredible sustained effort. It flies steadily at 10 miles an hour and can achieve 30 miles an hour in spurts. On the northward flights, the only limitation on distance appears to be the presence of milkweed. Some monarchs have been seen as far north as Alaska. Dr. F. A. Urquhart of the Royal Ontario Museum of Zoology and Paleontology, who has studied the flight of monarchs by tagging them with thin paper slips, found that one butterfly tagged in Ontario in September had reached San Luis Potosi in Mexico – some 1,870 miles away – by the following January.

While this flight remains the longest known, records of migrations of 1,000 miles or more are not uncommon in Dr. Urquhart's files. Several tagged monarchs have been recovered in Texas only two or three months after they left Ontario.

Significantly, there is no record of a tagged monarch returning to the place where it was first seen. The life span of a monarch is about nine months, and while some monarchs are believed to make round trips, scientists have no definite proof of this. It seems that most of the butterflies make just one leg of the long migratory journey.

That adds to the basic mystery of monarch migration – the question of guidance. To answer this question, scientists have only speculations. Some believe the butterflies find their way over thousands of miles by orienting themselves according to the sun. But it is known that other insects migrate at night, when they cannot use this method. The theory has support because studies with birds have shown that the position of the sun may play a key role in orientation of migrating birds.

Another theory is that male monarchs lay "scent trails" through the sky to establish the migratory route. The males do appear to take the lead in the southward migration, and the theory could also explain why monarchs cluster year after year on the same trees, which most of them have never seen before. It is known that some insects are sensitive to surprisingly minute concentrations of scent, but proof of this theory is lacking.

Some entomologists maintain that the monarchs and other migrating insects orient themselves by detecting the earth's magnetic field. Admittedly this is pure speculation.

Whatever the answer is, it must include solutions to some puzzling observations. One observer in a boat on the middle of a lake watched groups of south-bound monarchs which made a sharp left turn in the air above the water and then made a sharp right to resume the original course. In other observations, insects have flown up one side of a tree and down the other rather than fly a few yards to one side or another to avoid the tree. C. B. Williams, a leading authority on insect migration, once saw white butterflies in East Africa beat themselves repeatedly against the wall of a bungalow and then fly over the structure rather than detour around it.

Just as puzzling is the question of why insects migrate at all. While the southern flight of monarchs is triggered by the shortening day, and the trip is made quickly to avoid the cold, the same reasoning cannot be used to explain their northern flights. The reasons for which other insects migrate are just as obscure, with one possible exception.

In the early years of the century, one of the puzzling questions of entomology was the relationship between the migratory locust and the non-migrating grasshopper. While most individuals could be classed in one group or another, there were a few puzzling "intermediates" that defied classification. The question was answered in an elegant experiment.

Eggs from a single migratory locust were divided into two groups. One batch was hatched and the young insects fed in a confined space, and they duly developed into migratory locusts. Members of the other group were kept isolated from each other – and developed into non-migrating grasshoppers, different in almost every feature.

Later study showed that every migrating locust had a non-migrating grasshopper form. Depending on conditions, one form could be transformed to the other "phase," as it is called. While grass-

The painted lady, *Venessa cardui,* is also known as the "thistle butterfly." Second only to the monarch butterfly in migratory travels, the species is found throughout much of the habitable world with the possible exception of South America.

hoppers have been found in later work to migrate on occasions, their movements are not as conspicuous or as damaging to crops as those of the locusts.

Entomologists attempting to repeat the experiments on migrating butterflies and moths have achieved some interesting results. In one series of experiments, crowding produced phase differences in the army worm moths and lesser army worm moths, migrating species found in South Africa. Phase effects have also been demonstrated in the silver-Y moth, another migrating species. But similar changes have also been produced by crowding together members of a moth species that is known not to migrate.

One reason why many of these questions remain unanswered is that entomologists have only taken insect migration seriously for a relatively brief time. Several decades ago, most reports of mass insect flights were attributed to winds carrying the insects, which were thought to be following the path of least resistance. But diligent study of a number of sighting – much of it due to C. B. Williams – has shown that butterflies and moths are just as likely to fly against the wind as with it.

While accounts of migrating butterflies have accumulated in recent years, most older accounts are limited to observations of mass flights. These can be impressive indeed. In 1888, monarchs were seen flying over Maryland in a great swarm that extended as high as the eye could see. In the year 1508, a swarm of butterflies flew south over the coast of France "so thick as flakes of snowe, that men beinge a shutynge in St. Petars fields without the towne of Calleys (Calais) could not see the towne at foure of the clock in the aftarnone, they flew so highe and so thicke." Columbus, on his second voyage of exploration in 1494, saw a swarm of butterflies near Cuba that was so immense "as even to darken the sky."

One butterfly that often figures in these reports is the painted lady, *Vanessa cardui,* which is ranked second only to the monarch in its migratory travels. Migrations of the painted lady have been recorded in North America, Europe, South Africa, Pakistan, and Australia. In the Americas, the painted lady winters in Mexico and flies north in the spring. The northward flights can be very impressive, with swarms numbering in the millions. But there are only a few scattered records of return flights, suggesting that the southward trip is undertaken by individual butterflies, rather than by large numbers.

On the other side of the Atlantic, the painted lady breeds in the desert areas of North Africa. In the spring the butterflies fly north across the Mediterranean, arriving in England in June, and sometimes going as far north as Iceland. The painted ladies which breed south of the Sahara fly south in September, which is spring in the Southern Hemisphere.

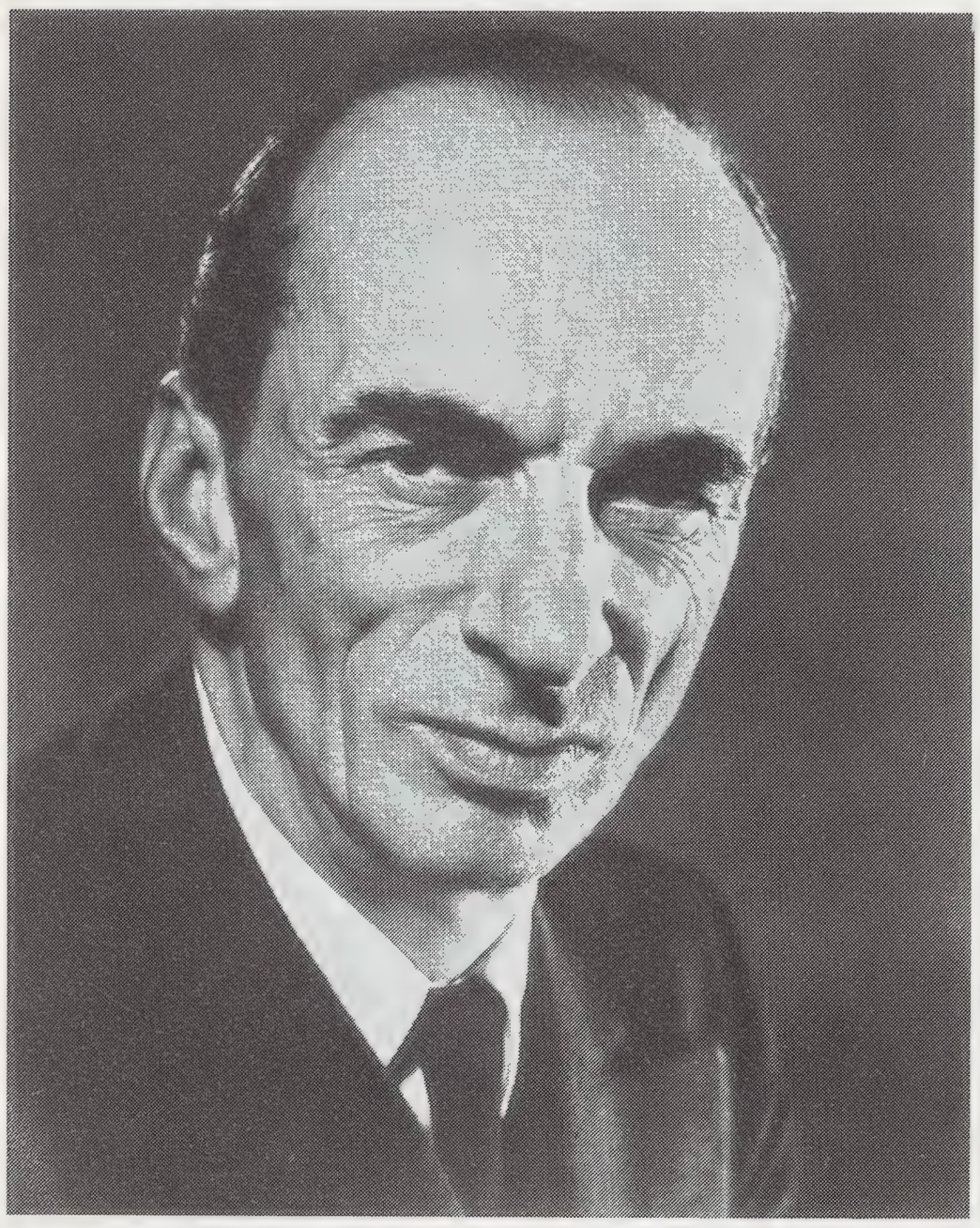
The painted lady has been the subject of some remarkable sightings. A swarm was seen flying over Pakistan at an altitude of 17,000 feet, the record elevation for migrating insects. And in 1869, a traveler in the desert near the Red Sea saw enormous numbers of painted ladies emerging from their chrystalids and flying off immediately toward the sea.

Those butterflies that do not fly in swarms are less likely to be noticed. The monarchs, for example, usually fly in groups of two or three, gathering in large numbers only to roost for the night or to settle on a favorite tree when they reach their destination. The cloudless sulphur butterfly, another American migratory butterfly whose yellow color makes it conspicuous, flies steadily and determinedly to the south in the autumn, but it takes a trained eye to detect the pattern. The clouded yellows fly as individuals, and only if an observer happens to note that each butterfly is heading in the same direction does he become aware of the pattern.

Despite all the difficulties of getting accurate observations, the number of butterflies and moths listed as migrants has increased steadily in the past few decades. Of the nearly 70 butterfly species in England, for example, 17 are known to be migrants. Of the 18 species of hawk moths, nine are listed as migratory. "Nearly 50 of the other larger moths could be put on a list of proved or suspected immigrants," wrote C. B. Williams, "but of the hundreds of smaller species only about 20 are as yet suspect. Only time will show how incomplete our knowledge is . . . "

As that knowledge becomes more complete, many of the blank spaces in the field of insect migration are certain to be filled in. But even after the scientists are able to fix precise reasons for the feats of the monarchs and painted ladies and their migrating relatives, the achievements of these small, stubborn fliers who follow sky paths invisible to man will remain every bit as impressive.

animal kingdom
NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION
REPORTS



FAIRFIELD OSBORN
January 15, 1887 – September 16, 1969

Dr. Fairfield Osborn, one of the world's foremost conservationists, and president of the New York Zoological Society from 1940 to 1969, when he became Chairman of the Board of Trustees, died September 16, 1969. He was 82 years old.

Because of his stewardship of the Zoological Society's Bronx Zoo and New York Aquarium, some people called Fairfield Osborn "the greatest showman since Barnum."

Beneath his showmanship, however, Dr. Osborn had a troubled scholar's concern about man's future on earth, a concern which was strongly expressed in his two popular books, *Our Plundered Planet* (1948) and *The Limits of the Earth* (1953).

In *Our Plundered Planet,* which the National Education Association selected as "outstanding book of the year," Dr. Osborn wrote: "The tide of the earth's population is rising, the reservoir of the earth's living resources is falling. Technologists may outdo themselves in the creation of artificial substitutes for natural subsistence, and new areas, such as those in tropical or subtropical regions, may be adapted to human use, but even such resources or developments cannot be expected to offset the present terrific attack upon the natural life-giving elements of the earth. There is only one solution: Man must recognize the necessity of co-operating with nature. He must temper his demands and use and conserve the natural living resources of this earth in a manner that alone can provide for the continuation of his civilization. The final answer is to be found only through comprehension of the enduring processes of nature. The time for defiance is at an end."

Although sometimes referred to as "a prophet of doom," Dr. Osborn regarded himself as an optimist. He had profound hopes for the future if man would equate himself more with his environment and with his potential.

Fairfield Osborn was born on January 15, 1887. He was the son of Henry Fairfield Osborn, university professor (Princeton and Columbia) and paleontologist, who for 25 years was president of the American Museum of Natural History in New York City. In 1895 when "Fair" was seven years old, his father became one of the founders – and later the president for 16 years – of the New York Zoological Society.

As a child he kept pheasants and snakes, fish and crocodilians at his family's homes in New York City and Garrison, New York. He maintained his animal collections through prep school at Groton, where in his bedroom, he had white mice, a pet flying squirrel, a white rat, miscellaneous

insects, eight or ten ring-necked doves roosting on a canoe paddle, and a baby alligator.

After Princeton University (Class of '09), Dr. Osborn spent a year at Cambridge University in England. Later he worked as a railroad track layer in Nevada for a brief period.

In 1914 he married Marjorie Lamond, and in World War I he was a captain of field artillery in the American Expeditionary Force. After the war he went to Wall Street and the investment business. But his interest in natural science continued, and in 1922, he became trustee of the New York Zoological Society.

Dr. Osborn became president of the society in 1940 and embarked upon a long-range program of exhibiting wildlife in natural surroundings instead of behind bars. He also encouraged oceanographic research at the New York Aquarium. The Osborn Laboratories of Marine Sciences, built at the aquarium's new site at Coney Island, were named in his honor.

Dr. Osborn, who in *Who's Who* called himself a naturalist, was also chairman of the board of the Conservation Foundation, whose interests and influence are worldwide. On April 23, 1969, the American Society of Planning Officials awarded its medal to Dr. Osborn and the Conservation Foundation "for their influential role in the fight to improve the quality of human life."

Among his many honors were the Audubon Medal of the National Audubon Society, the Medal of the City of New York, the Prix Manley Bendall of the Institute Oceanographique of France, the first Conservation Medal of the San Diego Zoological Society, and the Gold Medal of the New York Zoological Society.

He held honorary degrees from New York University, Princeton University, Kenyon College, University of Buffalo, Hofstra University, and Williams College.

Dr. Osborn was an Honorary Member of the Explorers Club, a Fellow of the New York Academy of Sciences, Honorary Vice President of the Fauna Preservation Society of London, and a Foreign Fellow of the Zoological Society of London.

He is survived by his wife and two daughters, Mrs. R. C. Murphy, Jr., of Philadelphia and Mrs. W. M. Roth of San Francisco.

Cuban Crocodile

(The following is a digest of a report on the Cuban crocodile, a threatened species, compiled for ANIMAL KINGDOM by a prominent Cuban scientist. The information in the report is dated May 10, 1969.)

More than 3,000 wild Cuban crocodiles have been rounded up in their native swamps and placed in protected enclosures or "corrals" in one of the swamps. The corrals are located near the Laguna del Tesoro in the Zapata Swamp of south-central Cuba.

The crocodiles were removed to the corrals from other areas of the Zapata Swamp and from the Lanier Swamp of the Isle of Pines because their wilderness habitat is threatened with destruction. Much of the land is being put to agricultural use.

Only a few Cuban crocodiles, mostly small animals, remain in the wild. While a sizeable population would seem to be protected in the corrals there is another, more subtle, threat to the existence of the Cuban crocodile. American crocodiles also live in the protected areas and these are interbreeding with the Cuban species. With the proper controls, however, interbreeding can be eliminated and the corrals developed into a natural habitat for the Cuban crocodile.

The largest Cuban crocodiles now found on the island measure about nine feet long. Formerly Cuban crocodiles 15 feet long were found on the island.

Seattle's New Tropical House

Seattle, Wash. – According to Genesis, the serpent beguiled Eve and paradise was lost. The Seattle Department of Parks and Recreation's Woodland Park Zoo has restored Eden to the serpents – 88 of them in fact. They are housed in the zoo's new Tropical House, which was dedicated last February.

The Tropical House also has lizards, alligators, turtles, and a host of birds, in tropical forest exhibits that have made the new building the most popular attraction in the 90-acre zoo.

Construction of the Tropical House, which cost nearly $400,000, is the result of a cooperative

effort by the architect, builder, zoo staff, and members of the Seattle Zoological Society.

The idea in the beginning was, according to Frank Vincenzi, zoo director, to "bowl over the visitor by a feeling he's in a tropical forest the minute he steps inside the door."

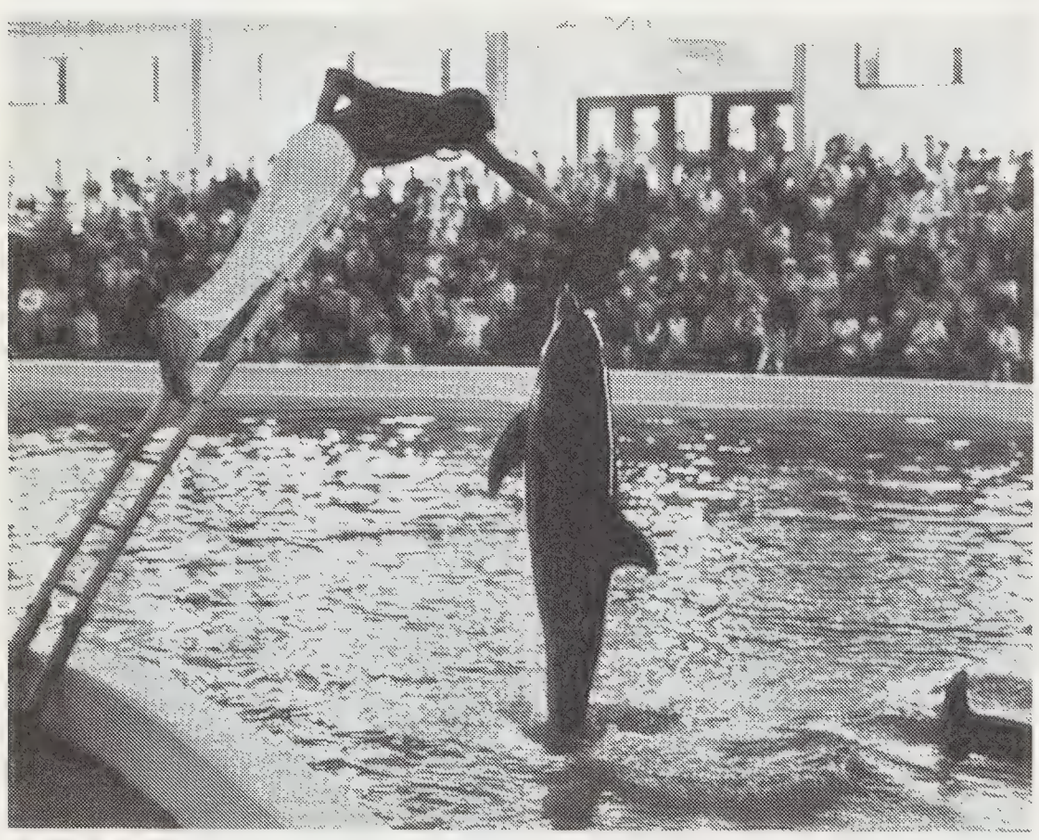
Architect Fred Bassetti went a step further. He designed the building so that it created the feeling of a tropical forest on the outside of the building as well, sculpturing the earth to blend with the concrete structure. "We wanted a building that would age gracefully," Bassetti explained. The rough-form boards give a natural texture to the concrete achieving the intended effect.

The building, Bassetti said, "is introverted, focusing upon exhibits; continuous flowing concrete walls form a muted background for the creatures. Circular, the radial circulation pattern guides visitors between cages for snakes and larger pens for tortoises, iguanas, and alligators. A clerestory roof admits daylight into the larger cages, which are of double glass on all snake exhibits."

Actually, the Tropical House serves both reptiles and nocturnal mammals, although the nocturnal portion is as yet unfinished.

The crocodile and alligator sections have large pool areas with sandy beaches and tropical plants. Cement trees were constructed and draped with Spanish moss for authenticity.

The concrete walls of the building have the appearance of bleached cedar. Plantings lend to the tropical forest atmosphere, and taped jungle sounds, the cry of tropical birds, and the grunts of an alligator heighten the tropical illusion.



Brookfield Zoo Hosts Art Exhibit

Brookfield, Ill. – Animal portraits in the subtle, delicate shadings of sumi-e (Japanese brush painting) were placed on display this summer at Brookfield Zoo, near Chicago.

"This exhibit emphasizes the importance of the zoo as a subject for artists," said Dr. Peter Crowcroft, zoo director. "It started as a display but people wanted to buy the paintings, so we're selling them for $18 to $90. That gives the zoo a small profit."

Artist Ryozo Ogura learned the difficult sumi-e technique as a youth in Japan. He came to the United States in 1919 and has been teaching in the Chicago areas since World War II.

He uses rice paper, which has no starchy filler or glaze to impede the free flow of ink. His water-soluble inks, imported from Japan in stick form, are made from fish-bone glue and the soot from burning pine trees. They are applied with special brushes, with cores of hard, water-resistant bristles, a middle region of moderate texture, and soft-haired fringes.

Many of Mr. Ogura's works are inspired by animals he observes at Brookfield Zoo. He delights in drawing small creatures: mammals, birds, katydids, crayfish, and frogs. Cats are a special favorite, depicted in abstract modifications of the traditional sumi-e technique.

The sumi-e display is in the zoo's special exhibits building, which in the past two years has also housed, among other things, a history of zoos and a colorful collection of commemorative postage stamps bearing animal illustrations.

The building also contains a bookstore specializing in natural history materials, and cages where live animals demonstrate biological principles. These include camouflage (snakes), social relationships (rhesus monkeys), and territoriality (fishes).

Europe's largest "Dolphinarium" is the newest attraction at Kolmarden animal park, near Norrkoping on Sweden's east coast, where more than 1,000 wild animals – tigers, giraffes, polar bears, etc. – roam "free" in sheltered areas in the wide expanse of woodland.

THE bookshelf

CATCH A WHALE BY THE TAIL. *By Edward R. Ricciuti. Pictures by Geoffrey Moss. 61 pp. A Science I CAN READ Book. Harper and Row, Publishers, New York, 1969. $2.50.*

Books for children have been changing in recent years. It is still possible to find books about animals that talk, but a new kind of book is around now, about animals that behave like animals, without sacrificing any of their appeal. *Catch a Whale by the Tail* is a fictionalized account of the capture and release in an aquarium of a mate for the aquarium's resident beluga. Members of the New York Zoological Society will detect a familiar note in the story, which is based on the New York Aquarium's experiences with white whales and bolstered by Curator of Publications Ed Ricciuti's own participation in a whale-catching project in the far north.

The store of Robert and Roberta cannot fail to capture the imagination of any child just learning to read, and at the same time will teach the new reader a surprising amount of factual information about whales and whale-capturing. The book, one of the Harper & Row Science *I Can Read* series, is written simply, for the beginning reader, but lurking in its simplicity is a great deal of action, scientific fact, and good humor.

Joseph A. Davis

LOST WILD AMERICA. *By Robert M. McClung. Illustrated by Bob Hines. 240 pp. William Morrow and Company, New York, 1969. $5.95.*

Among the many recent books dealing with wildlife and its preservation, *Lost Wild America* stands out as an exceptionally concise and informative account of the history, present day status, and prospects for the future of many of our best known native animals. Practicing zoologists and conservationists surely will appreciate the wealth of documented material contained in this book. Of even more importance will be its impact on all other Americans, who cannot fail to be awed by such accounts as the extermination of the Steller's sea cow within twenty-six years after it was discovered in 1768, or the history of the passenger pigeon, a species calculated to have a population in the billions in 1810, yet which, through wanton slaughter, had been practically obliterated before the close of that century.

Pleasant touches in the book are the inspirational quotes that precede each of the seventeen chapters. Also, the author was both astute and fortunate in the selection of Bob Hines as illustrator.

The author, Robert McClung, has had a life long interest in zoology and for seven years was on the staff of the New York Zoological Society. His account of the natural history of our many species of threatened wildlife is both sympathetic and knowledgable. With this as a basis, he weaves the sequence of factors that have affected their survival. With facts and figures, he correlates population expansion, destruction of land and pollution of air and water, irresponsible hunting, commercial greed, and remedial action (too often belated) of international, federal, state, and local agencies. Credit also is offered generously to many individuals who have worked in the interests of wildlife.

Anyone at all interested in our native wildlife will read with regret of the thoughtlessness of our forebears, approve helpful activities that have been and are being sponsored, then surely pledge to more active participation in conservation methods and measures. A history that admits to the loss of over forty kinds of mammals and birds during the past 150 years, and countless others on the verge of extinction, must not be repeated.

Grace Davall

BIRDS OF THE ATLANTIC OCEAN. *Paintings by Keith Shackleton. Text by Ted Stokes. 156 pp.,23 identification plates and 15 oil paintings. The Macmillan Co., New York, 1968. $12.95.*

First printed in Great Britain, this book is a colorful collection of sea bird portraits depicted in oils and gouache by Keith Shackleton. Unlike most books of its type, wherein an artist is commissioned to illustrate the work of an ornithologist, this volume was done in reverse, with the writer, Ted Stokes, chosen to compliment Mr. Shackleton's paintings. The book is pleasant enough on the whole but falls into the trap of trying to be a general guide to the birds of the Atlantic Ocean, an ambition which it does not and cannot fulfill. Mr. Shackleton's paintings, particularly those executed in oils, are of very high quality and only fall short of the mark in areas where Mr. Shackleton has no real knowledge of the species depicted.

The rock-hopper and macaroni penguins on page 21 show little real resemblance to the actual birds. The pelican plate on page 71 exhibits the same failure. The American white pelican, *Pele-*

canus erythrorhynchos, and the brown pelican, *P. occidentalis,* appear as birds of like-size, and two studies of the pink or red-backed pelican, *P. rufecens,* show the species as white with a horny shield on the bill. This bird is actually silver-gray; the only pelican that sports the seasonal growth on the bill is the American white pelican.

By and large, however, the paintings are correct and present very pleasing compositions, particularly in the instances where many species are shown on a single plate. In all, 137 forms are illustrated.

The correlation of illustrations and text is not as successful. Four of the birds described are not even depicted, and in several instances, i.e., Thayer's gull, *L. argentatus thayeri,* the illustration is only of the bird's head and not definitive for a subspecies.

In the case of the Ascension frigate bird, *Fregata aquila* (page 85), the author describes the species as being all black or dark brown in both sexes with immatures having a white head. The painting on page 89 shows a bird labeled Ascension frigate bird with a completely white breast.

Albatrosses are another weak point. Always difficult to identify and place, they become even more confusing here. An instance in point is the gray-headed or yellow-nosed albatross, *Diomedia chrysostoma,* shown on the range maps to be nesting on Tristan de Cunha and Gough Island instead of the Falkland Islands.

The synonyms given for common names are helpful.

Joseph Bell

THE WORLD OF THE PRONGHORN. *Text and Photographs by Joe Van Wormer. 190 pp. J. B. Lippincott, Philadelphia and New York, 1969. $5.95*

This is a well written documentary of one of our most striking native animals. The information is accurate and is presented in a way that the general reader will learn a great deal about this unique animal.

The author has a good understanding of and feeling for wild life and conservation. While realizing that proper game management and multiple use can apply to the pronghorn, the author does not tie this to conservation as well as might be done. If the reader can come away with the same attitudes and feelings that the author expresses, this book will help the cause of conservation.

Mr. Van Wormer points out that pronghorn hunting is very popular, but if properly regulated, it most likely will have no adverse effects on the pronghorn's future. Improper management and careless hunters could spell disaster for the pronghorn; however, the most important current need is for space, and the present habitat destruction is probably the greatest threat to the species' continued survival.

Mr. Van Wormer's hard work in researching his topic has been rewarded with a book filled with accurate and detailed data. The wealth of photographs adds greatly to its value and interest. The photographs are all good and show many details of pronghorn behavior that would be very difficult to describe.

A little more about the actual feeding habits of the pronghorn, or at least a little more on the specific plants, would have added to the book. More information on their relationships with other animals would also have been useful.

In general, the book should be a welcome addition to any nature lover's library. Anyone interested in wild life and game management will find this book fascinating and enjoyable.

Donald Bruning

ABOUT THE authors

Edward Edelson is a science writer and editor whose work appears often in *Animal Kingdom.* **U. Erich Friese** is assistant curator of the New York Aquarium. **Richard L. Penney** is a research zoologist on the staff of the Institute for Research in Animal Behavior. **Katherine Ralls** is a member of the staff of The Rockefeller University. **Alexander F. Skutch** writes of the birds of tropical America from his home in Costa Rica.

ILLUSTRATION CREDITS

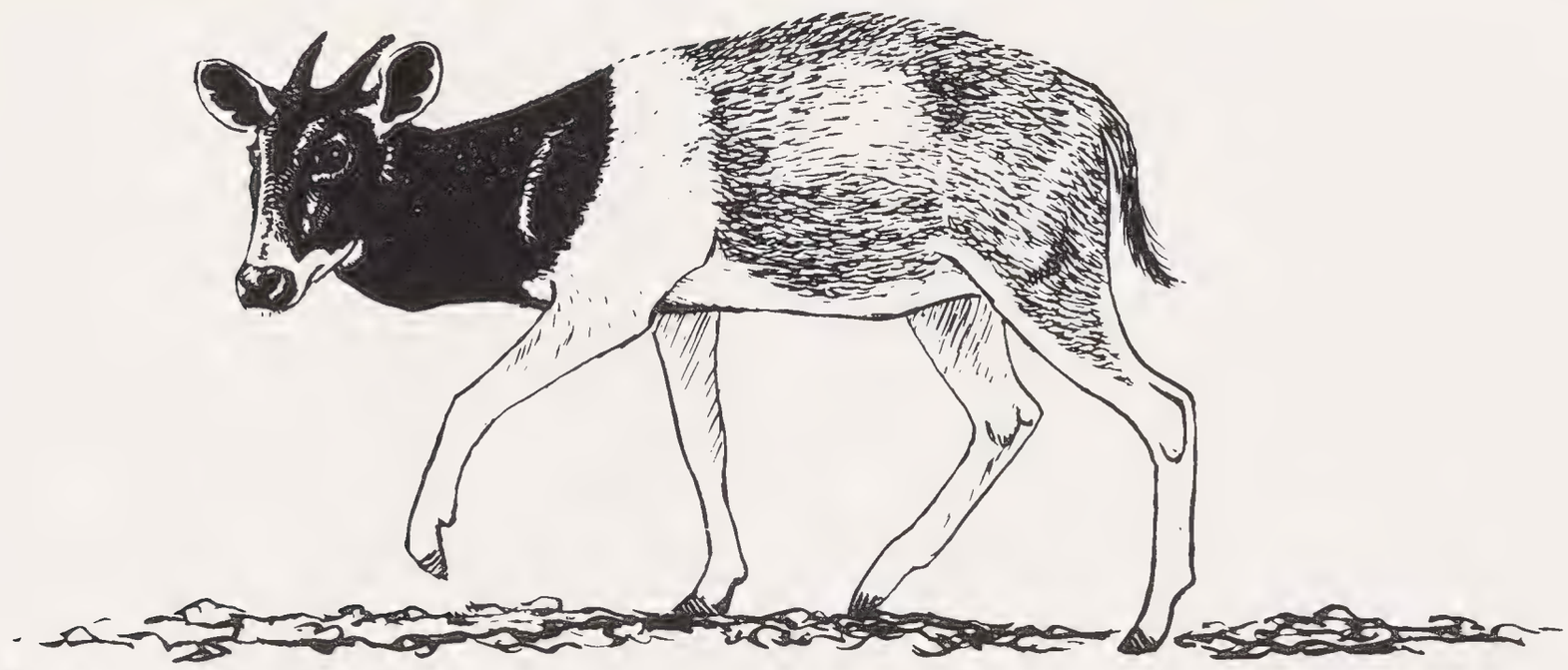
Front Cover: William Austin; pp. 2-6; Richard L. Penney; p. 7: N.Y.Z.S., William Meng; p. 8: N.Y.Z.S., Joseph A. Davis, after E. L. Poole; p. 10: Alexander F. Skutch; pp. 12-13 (top): N.Y.Z.S., Robert A. Morris; pp. 12-17: N.Y.Z.S., William Meng; pp. 18-21: N.Y.Z.S., U. Erich Friese; p. 23: Hugh M. Halliday from National Audubon Society; p. 24: Alvin E. Staffan from National Audubon Society; p. 26: Lynwood Chace from National Audubon Society; p. 28: N.Y.Z.S.; Inside Back Cover: N.Y.Z.S., Joseph A. Davis; Back Cover: N.Y.Z.S., U. Erich Friese.

Design by B. J. Johnson

DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo



Jentink's Duiker

Cephalophus jentinki

Jentink's duiker is one of the rarest and most little-known mammals. Few specimens have been acquired by museums since the original three animals on which the description of the species was based. No living Jentink's duiker had been brought out of Africa until September 1968, when two females arrived at the Henry Doorly Zoo in Omaha, Nebraska. Apparently, this antelope has a very limited area of distribution, as it has only been reported from the vicinity of the West African republic of Liberia.

Jentink's duiker is strikingly marked with black head and neck separated from its grizzled "salt and pepper" body by a band of white hair across the shoulders. Because of its large size and rarity, some scientists have suspected that Jentink's duiker was only a color variant of the yellow-backed duiker, *Cephalophus sylvicultor.* Recent studies have, however, established that the two animals are quite distinct species.

In 1960, Hans-Jurg Kuhn carried out an extensive search for Jentink's duiker in Liberia and succeeded in obtaining the nearly complete skin of an adult female and pieces of the skin of another specimen. The most interesting of Kuhn's discoveries was a young duiker, dark brown in color, which he describes and illustrates as being practically identical in appearance to a young black-backed duiker, *Cephalophus dorsalis.* Young black-backed duikers are a rather even dark brown in color and do not resemble the adults, which are chestnut brown with a broad black strip down the center of the back. Kuhn's animal seemed too large to be a young black-backed duiker, however, and the characteristics of the skull later confirmed the suspicion that this was a young Jentink's duiker. In 1967, a second young Jentink's duiker was captured, this time by Harry Gilmore, who was able to observe the change to the adult coloration as the animal matured. This difference in color between juvenile and adult duikers of the same species, and the close resemblance between young animals belonging to different species, may account for some of the difficulties in deciding just how many species of duikers exist. According to Kuhn, young yellow-backed duikers are black; young black duikers, *C. niger,* resemble their parents at birth, and the appearance of the young of some species, such as Ogilby's duiker, *C. ogilbyi,* is unknown.

The locality in which Jentink's duiker was first discovered is now the site of a giant Firestone rubber plantation. The total population of this rare antelope is probably not very large, and the species is threatened with extinction as its forest habitat is increasingly being managed for commercial purposes. Roads built for the use of foresters allow hunters easy access to previously inaccessible areas. Because of the difficulty of enforcement and the problem of identifying young animals, banning the hunting of Jentink's duiker would be of little use. The species' only hope for survival lies in a national park where all hunting is forbidden. If such protection is not soon provided, Jentink's duiker may disappear completely before even the most basic information about its behavior and ecology are discovered.

KATHERINE RALLS

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ABOUT THE COVER

Front: American alligator *(Alligator mississippiensis)* in the Everglades. A species unique to the United States, the American alligator has been receiving attention lately as conservationists attempt to save the animal from extinction at the hands of poachers after its valuable hide. A battle in the alligator war was won recently in New York City. For a report on "The Year of the Alligator," see *Animal Kingdom Reports* on page 30.

Back: Lowland gorilla *(Gorilla gorilla gorilla)* is found in the great African forests from Nigeria to the Central African Republic.

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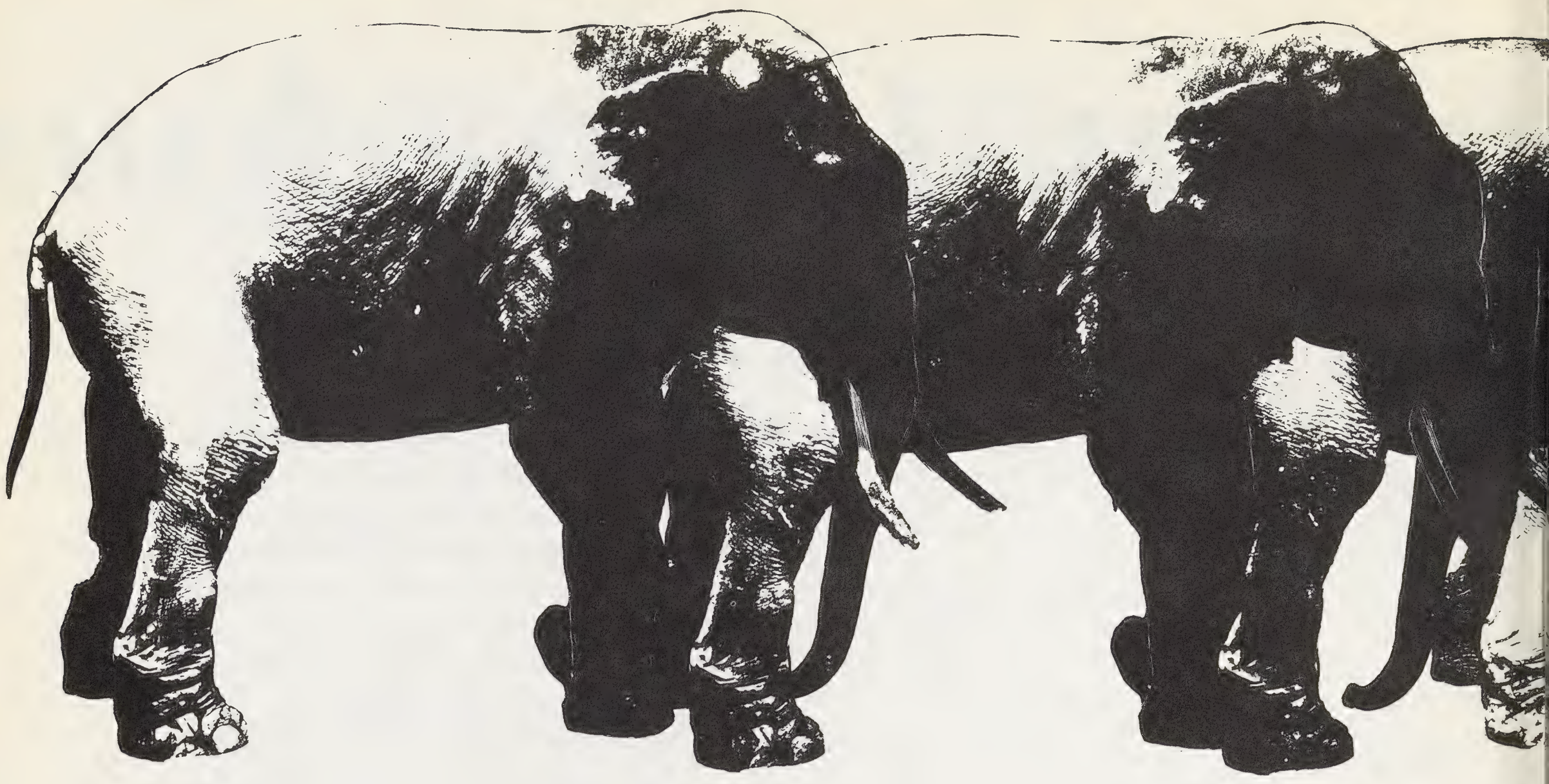

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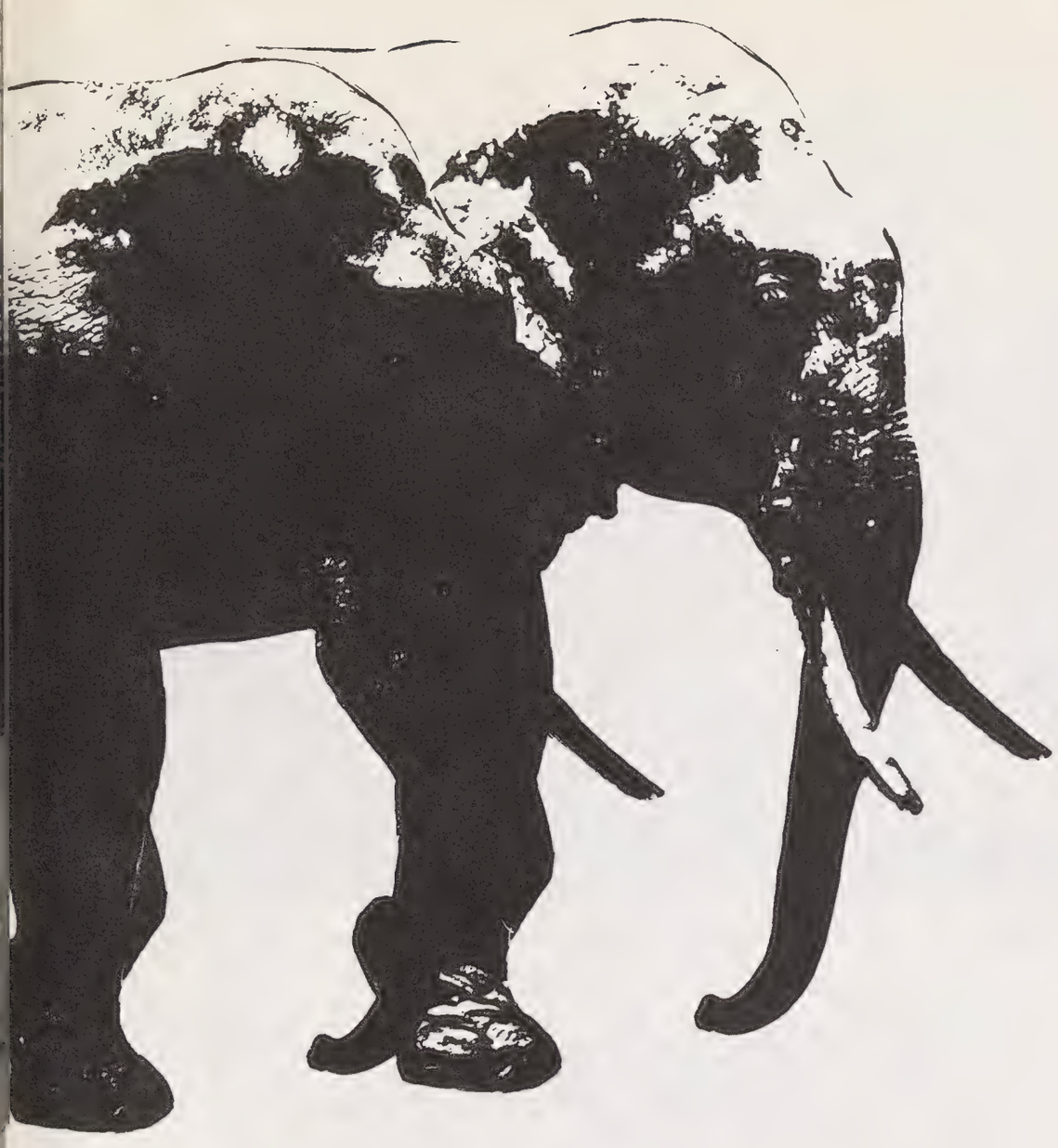


A Zoo Success Story
by Stan Federman

If the zoo world held a contest for "Father of the Century," the Portland (Oregon) Zoo's 21-year-old bull Asiatic elephant, Thonglaw, would probably walk away with top honors. Thonglaw has fathered seven youngsters in the last seven years. His most famous offspring is Packy, who was born April 14, 1962—the first elephant to be born in the United States in 44 years. Since then, Thonglaw has sired three more sons and three daughters, to launch an elephant dynasty the Portland Zoo expects will continue for many years to come.

Thonglaw, who now stands 9 feet, 10 inches tall and weighs 12,000 pounds, was born in Cambodia and named after Thonglaw Punyanitya, a Bangkok animal trader. The elephant was sold to American animal trader and trainer, Morgan Berry of Woodland, Washington. Thonglaw joined a small herd of Asiatic elephants that Mr. Berry maintained in Washington, mostly for exhibitions given at varied West Coast cities during the 1950's.

Mr. Berry had sold the Portland Zoo several of its larger exotic animals and sometimes rented space at the zoo's elephant house to winter one or two of his pachyderms. In 1960, Berry brought Thonglaw and two females, Belle and Pet, to the Portland Zoo, temporarily—he thought—to join the zoo's two elephants, Rosy and Tuy Hoa.

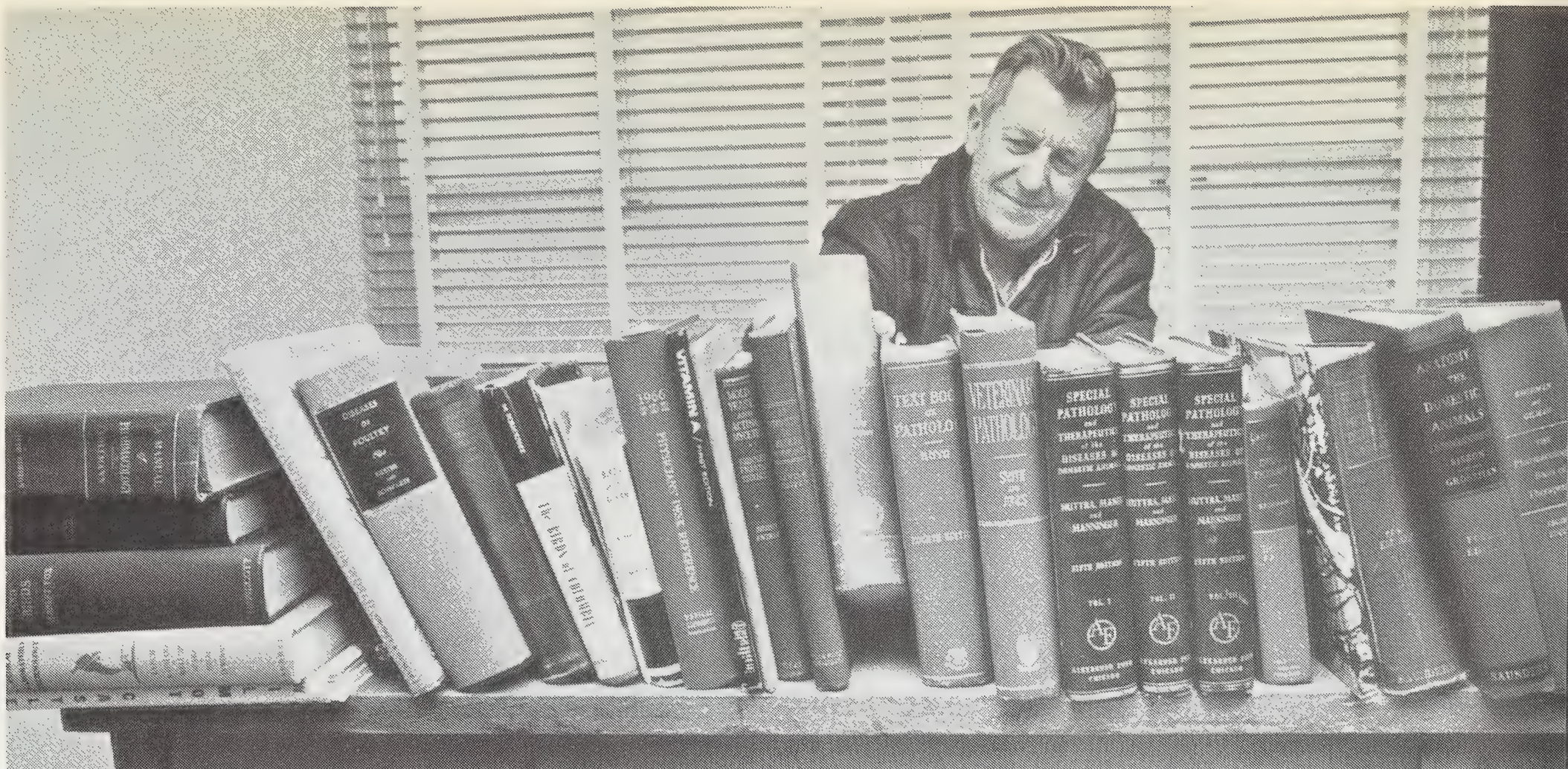
Rosy was the zoo's first elephant. She was presented to the zoo in September 1953 by the late Oregon state legislator, Austin Flegel, who bought her while he was director of a United States economic mission to Siam (Thailand). Three years later, the zoo received Tuy Hoa as a gift from Portland engineer Orville Hosmer. The elephant had been presented to Mr. Hosmer by the people of Vietnam's Tuy Hoa Valley after he helped restore that area's irrigation works, destroyed during the French-Indochina War.

With the arrival of Thonglaw, the Portland Zoo launched its breeding program.

After Belle gave birth to Packy during the 1962 Easter week, the duo became the darlings of the Portland public. Portlanders subscribed $30,000 to purchase the mother and son from Mr. Berry. He had been offered as much as $50,000 for the pair but wanted them to remain in Portland. Then, rather than break up the elephant family, Mr. Berry gave both Thonglaw and Pet to the city as a gift.

As Thonglaw's harem grew, so did the number of his progeny.

Me Tu, born October 3, 1962, the daughter of Rosy, was the zoo's second baby elephant. She


TEXT BOOK OF PATHOLOGY
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A SYNOPSIS OF THE DISEASES OF ANIMALS

Veterinarian Matthew Maberry catches up with some elephant record-keeping at the Portland Zoo.

was followed by Dino, son of Pet, who was born September 15, 1965, and later sold to the Spokane (Washington) Zoo.

Nine days after Dino's birth came Hanako, daughter of Tuy Hoa. She was named by the Japanese school children of Sapporo, Japan, the sister city of Portland. Hanako means "Flower Child" in Japanese.

Noel, the zoo's fifth baby and the second daughter of Rosy, was born December 3, 1965. She was later sold to Chicago's Brookfield Zoo after that zoo's Babe came to Portland in 1964 to mate with Thonglaw and failed to conceive. The mating represents Thonglaw's only failure to date as a father. Portland Zoo-men believe Babe, who was nearly 30 at the time, may have been barren.

Rajah, the zoo's sixth baby and the second son of Pet, came along on August 9, 1966. Finally, there was Droopy, who was born September 29, 1968, to Effie, an elephant then owned by the Oakland (California) Zoo and brought to Portland for mating purposes. Droopy, however, was malformed and died six days after birth, the only infant casualty in the Portland breeding program.

At the present time, Tuy Hoa is pregnant again. So is Winky, another female visitor from the Madison (Wisconsin) Zoo.

The Portland Zoo has in seven short years broken all productivity records. Its elephants, which now number 10 (including Effie, which Oakland no longer wants) have become world-famous. In addition, as a result of the seven births, the herd has contributed new and invaluable knowledge about elephants.

Thonglaw, of course, is the key to the herd. He is probably the most prized elephant in captivity. Thonglaw is normally a fairly easy-going animal who gets on well with his Portland keepers. But like any other bull elephant, Thonglaw can become quite dangerous during his periods of "musth."

Musth is a periodic glandular change in mature bull elephants which sometimes can produce a period of irritability. After every attack, which may last three days to three weeks, the bull must be trained to respond once more to his keepers.

Elephants have usually not been bred in captivity. The first elephant arrived in the United States in 1796, but prior to Portland's success only six babies had been born in the nation.

Much of Portland's breeding success has been linked to its excellent elephant housing facilities, probably among the finest available at any zoo in the world. A recent $75,000 addition has provided further help along this line. The elephant area includes seven large, separate indoor rooms plus a major indoor holding area. All rooms have doors operated by remote control, which permits the movement of elephants from room to room without keepers having to get in with them. All rooms are electrically heated for the animals' comfort on cold days.

There is also a large outdoor exercise compound, surrounded by a six-foot moat separating the compound from spectators. A pool is at one end of the compound and is constantly used by the herd.

Portland Zoo Director Jack Marks, Morgan Berry and his son Kenneth, and Al Tucker, the zoo's chief elephant keeper, have all contributed their talents towards building a healthy herd. But no man has done more to maintain that herd than the zoo's veterinarian, Dr. Matthew Maberry.

The 51-year-old Dr. Maberry is a pudgy

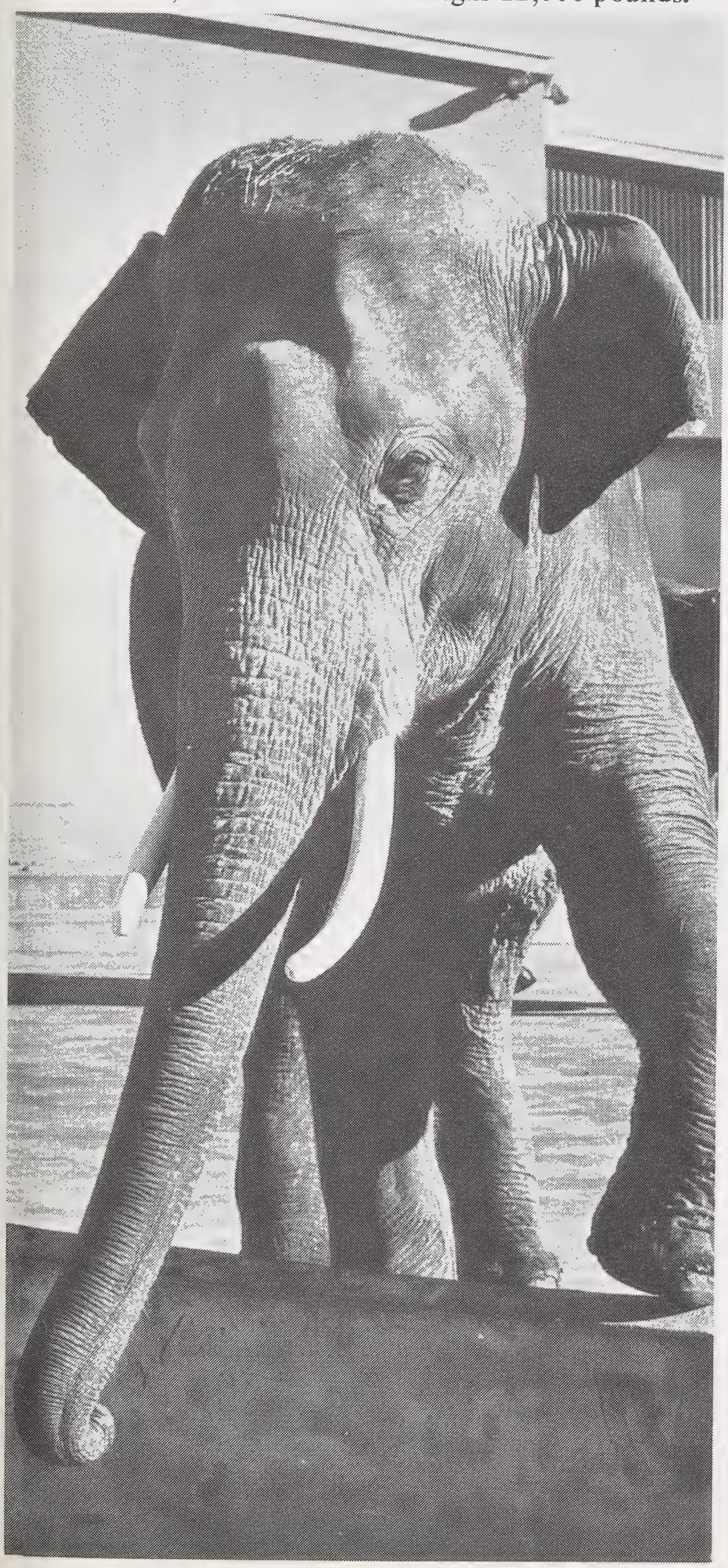
rumpled sort of man who appears as comfortable as an old shoe at his job. Portlanders refer to him as the herd's "mid-wife." He is a tough-minded pragmatic who has had broad wildlife obstetrical experience. He has helped deliver lions, tigers, buffaloes, and bears at the zoo—but until 1962, no elephants.

"I learned from the herd—and it learned from me," he grins. "And the one thing I learned most about bringing up elephants is that, unlike Garbo, they never want to be alone." He explains that elephants are basically a herd animal, and the zoo allows them to mingle together at all times, even during a birth.

"We make it a point to work with them, train them, and move in among them," he says. "We pet them, talk to them, and keep complete daily medical records on them." Portland's elephants roam freely in their rooms and outdoor compound, without the use of any leg chains or other confinement devices.

"What we have tried to do is establish a mutual affection between us and the herd—and we find it works very well," says Dr. Maberry. "Our elephants remain docile, affectionate, and easy to handle. Even at night we try to keep at least two or more of them together in one room. Except for medical purposes, the herd is always together."

Thonglaw, the zoo's 21-year-old Asiatic bull elephant, stands 9 feet, 10 inches tall and weighs 12,000 pounds.



The zoo has benefited economically from its elephants. Its $1,500 stud fee for Thonglaw is probably the highest for any zoo animal in the world. It has received $4,500 each from the sales of Noel and Dino. And during Packy's first year, zoo revenues increased more than $125,000 as more than one million visitors came to view the infant.

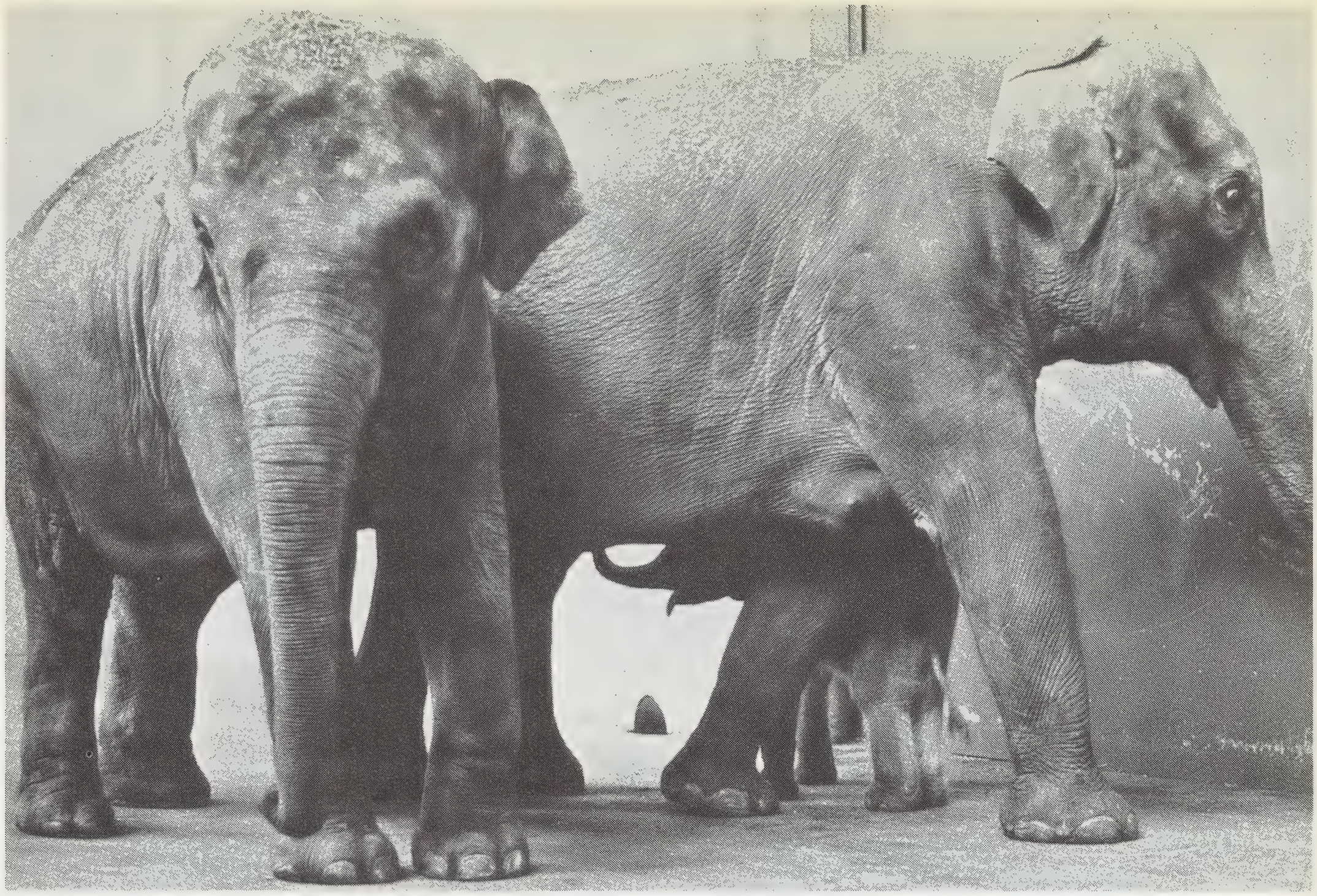
For zoo professionals, the Portland herd has brought a wealth of new educational information on raising elephants in captivity. It has been established through Portland's seven births that the time is between 21 to 23 months. The zoo has recorded four births at 21 months, two at 22, and one (Effie) at 23 months. Whether or not the longer gestation period might have resulted in Effie's baby's malformities is unknown.

Belle carried Packy exactly 635 days. Her pregnancy was the first ever recorded officially in captivity.

The Portland Zoo was also the first to record and successfully to study the heartbeat of an unborn elephant. This work was carried out by a team of doctors from the University of Oregon Medical School under the direction of Dr. Howard Tatum, who is also an ardent member of the Portland Zoological Society. Terminals of an electrocardiograph machine were attached to the thick hides of the pregnant elephants.

The heart study revealed that although the heart of the elephant mother-to-be would maintain a steady 47 beats per minute in her pregnancy, the baby's heart would beat a tatoo of 90 beats a minute. It was found, however, that the fetal heartbeat was fastest when first activated. It slowed down appreciably as it approached birth. Packy's heartbeat just before his birth was down to 60 beats a minute.

Dr. Maberry calls the start of Portland's elephant baby dynasty a "happening," rather than any planned situation. He recalls that Belle came into heat shortly after she and Thonglaw were brought to the zoo. "We discovered that the heat period of a cow lasts only a very brief time. In Belle's case, this was only a few hours. None of



Ten minutes after his birth, Packy was on his feet and five minutes later was noisily nursing.

our other cows have stayed in heat longer than two days."

Belle mated with Thonglaw only once (July 19, 1960) during her heat period. From that time on, Dr. Maberry kept a meticulous day-to-day chart on her pregnancy. The 10-year-old Belle showed signs of breast development by her fourth month of pregnancy, but other than this gradual buildup of her breasts, she showed few other symptoms. Always a quiet, docile animal, Belle behaved normally in succeeding months. The baby itself did not show on her until late in her pregnancy. "She didn't look the part until about her sixteenth or seventeenth month," says Dr. Maberry.

However, by her eighteenth month, Belle began to show quite a bit of discomfort, particularly when she lay down.

"We knew so little about elephant births," says Dr. Maberry. "There are few books of any use on the subject."

By the eighteenth month, Dr. Maberry both felt and heard the fetal heartbeat. As Belle continued to suffer discomfort, he thought it was "just a matter of time." The question was—when?

"We had nothing to go on. No one we knew had ever witnessed a zoo elephant birth. So we kept our fingers crossed and hoped for the best."

Meanwhile, Director Marks decided it was time to let Portlanders know they had a pregnant elephant on their hands.

The city immediately went elephant crazy.

Radio stations launched hourly "Belle Bulletins." Downtown stores did a land-office business in stuffed pachyderms. School children drew elephant pictures for their art classes. Newspapers created headlines with words like "Elephanticipating." The zoo was deluged with baby shower gifts for Belle. Florists sent huge paper mache booties with roses, the city's previous claim to fame.

Later, a city-wide contest to name the new baby drew almost 35,000 entries. Packy won over such suggestions as Belle Boy, Ding Dong, Porty, and Nogero (Oregon spelled backward).

By late January, the baby's kicking was quite visible—and ofttimes violent. The zoo men waited —and waited—and waited.

Everyone was nervous as the twentieth month passed. Both the Portland press and national news media kept calling the zoo every day asking: "When?" The delayed, or what was thought to be delayed, pregnancy brought letters of advice to the zoo from all over the world.

Dr. Maberry took no chances. He had a resuscitator, respirator, and special 110-volt electric prods available near the "maternity room" to prevent Belle from trampling the baby. He also had floodlights placed outside the bars and had borrowed a set of shipping room scales. "I had some crazy idea about weighing the baby right away," he grins.

The vet's problem was that he didn't know what to expect. Nearly a century before, a circus

elephant had attempted to trample each of her four calves when born and had refused to nurse them. Dr. Maberry wasn't taking any chances with Belle. He had plans to feed the baby a special formula based on powdered milk, if he had to.

During the last two weeks of Belle's pregnancy, Dr. Maberry actually slept at the elephant house and Director Marks was up to his ears with newsmen from all over the state, nation, and world. Belle had become the hottest animal story of the last few decades. When she finally did give birth, Mr. Marks collapsed from the strain of it all—and spent most of Packy's first day on earth resting up in a hospital bed.

The actual birth came about 5:58 A.M. ("Just like a woman," moans Dr. Maberry). It was preceded by about five hours of Belle squatting and straining in her maternity room that she shared with Rosy, Pet, and Tuy Hoa. Thonglaw was off by himself in another room. "But he knew what was going on," says Dr. Maberry.

Elephants use the "auntie" system when babies are born; the mother selects another female to stand by in case extra care or help is needed. In this case, Belle chose Pet. When Belle was in labor early that morning, she would lie down briefly and Pet would kneel beside her and gently massage her stomach with her knees. Whenever the pain was the sharpest, the other three cows would all crowd around Belle and, according to Keeper Tucker, "squeal in unison."

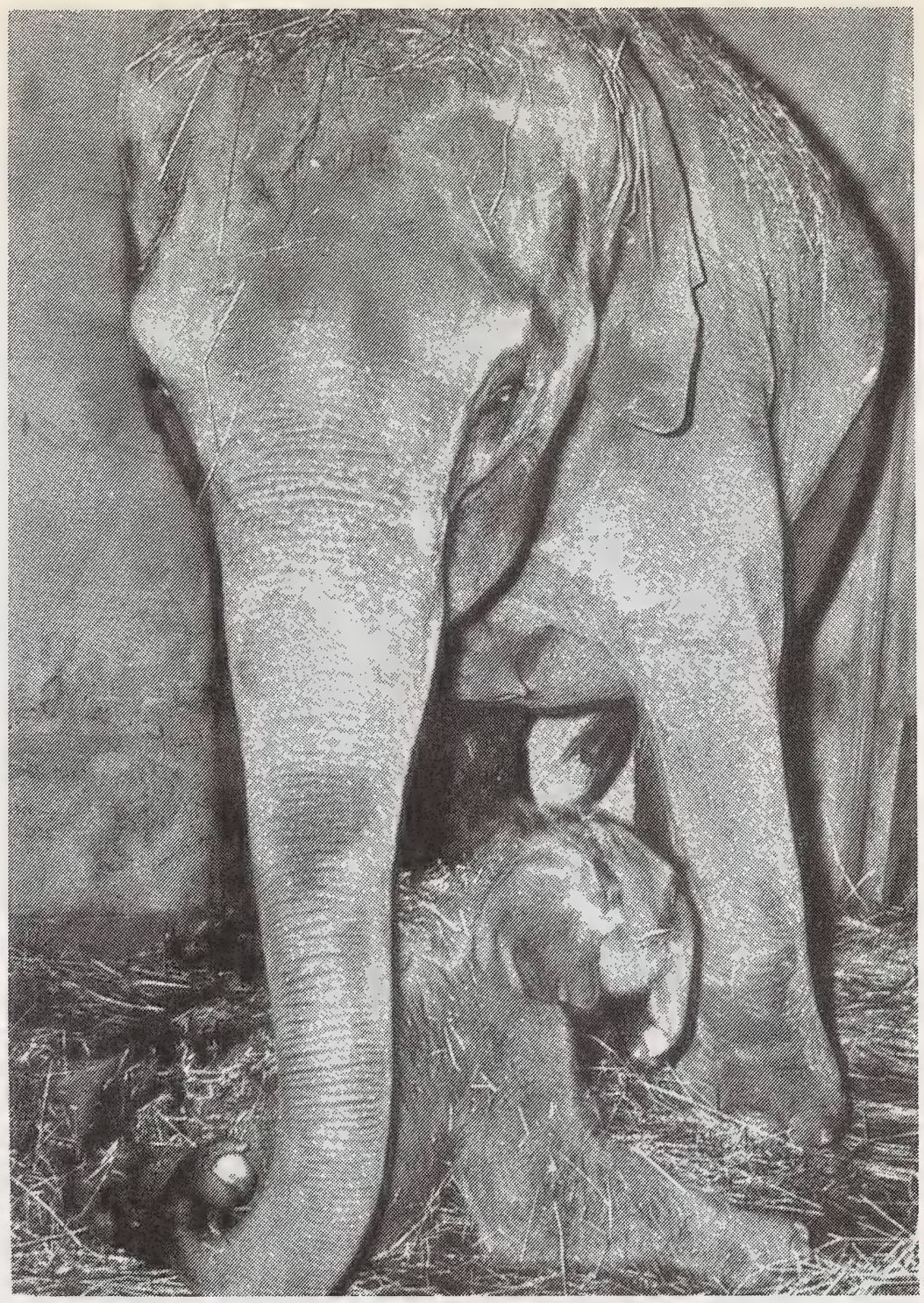
When the actual birth came, Pet proved to be too nervous for her "auntie" job. Both she and Tuy Hoa, who was also pregnant at the time, attempted to sit on the baby. It remained for Rosy, the queen of the harem, to help keepers hold off the other elephants.

Belle began bellowing loudly, her eyes wide and bulging, says Dr. Maberry. She was constantly straining and pushing against the walls and bars, throwing her head from side to side and alternately kneeling and standing. At about 5:50 A.M., she stopped bellowing and began to cross and uncross her hind legs. Then she began spinning around rapidly and silently in circles, pivoting on her forefeet.

And then—plop!

Suddenly it came, feet first, falling into a heap on the floor. "We were all outside the room watching the whole thing through the bars—and holding our breath," says Dr. Maberry. "Then Belle turned and started to kick the baby and we just about died from fright."

The vet and keepers were about to open the gates and rush in and try to save the baby, when they suddenly realized Belle was doing only what any good doctor would do—spank her baby to get its breathing started and get it on its feet.



Belle attempts to get the just-born Packy to his feet.

After keepers had moved Pet, Tuy Hoa, and Rosy to the outside compound following the commotion stirred up during the first few minutes of the birth, Belle continued gently to push the baby to its unsteady legs. It took her ten minutes to get him righted. Then with her busy trunk she led him to her breasts. He got the idea quickly and five minutes later was noisily nursing; his mother helped him hold his little trunk out of the way so he could reach the breasts with his mouth.

Packy's quick rising was unusual and the quickest of any birth. In most cases, the other babies flopped and threshed about on the ground from thirty minutes to two hours before they could stand up and nurse. Except for Belle, the other cows had relatively easy times of it; Tuy Hoa at one point in her labor pains apparently forgot what she was doing and actually went to sleep an hour before the baby came, awakening just in time to deliver it.

Zoo personnel remember above all the noise during Belle's delivery. The other elephants kept up a steady bellowing and trumpeting to herald the new arrival. All other births seemed somewhat quieter, although Mr. Tucker points out that trumpeting accompanied each birth.

Since the birth of Packy, Portland's zoo men have been better prepared. They know what to expect during pregnancies and how to handle it. Pet and Rosy both had easy births except for last

minute labor pains. Tuy Hoa's pregnancy with Hanako was perhaps the worst of all. She was down during her early months and at one time the zoo feared it might lose her.

"We tried a lot of things to bring her around," says Dr. Maberry. "We brought food and water to her to make it as easy as possible for her. We forced her to get up and walk around each day for exercise. She seemed to snap out of it by her fifteenth month and ended up having a fairly easy birth."

After seven years of raising elephants, Dr. Maberry has developed what he labels the "Maberry Theory" on caring for them.

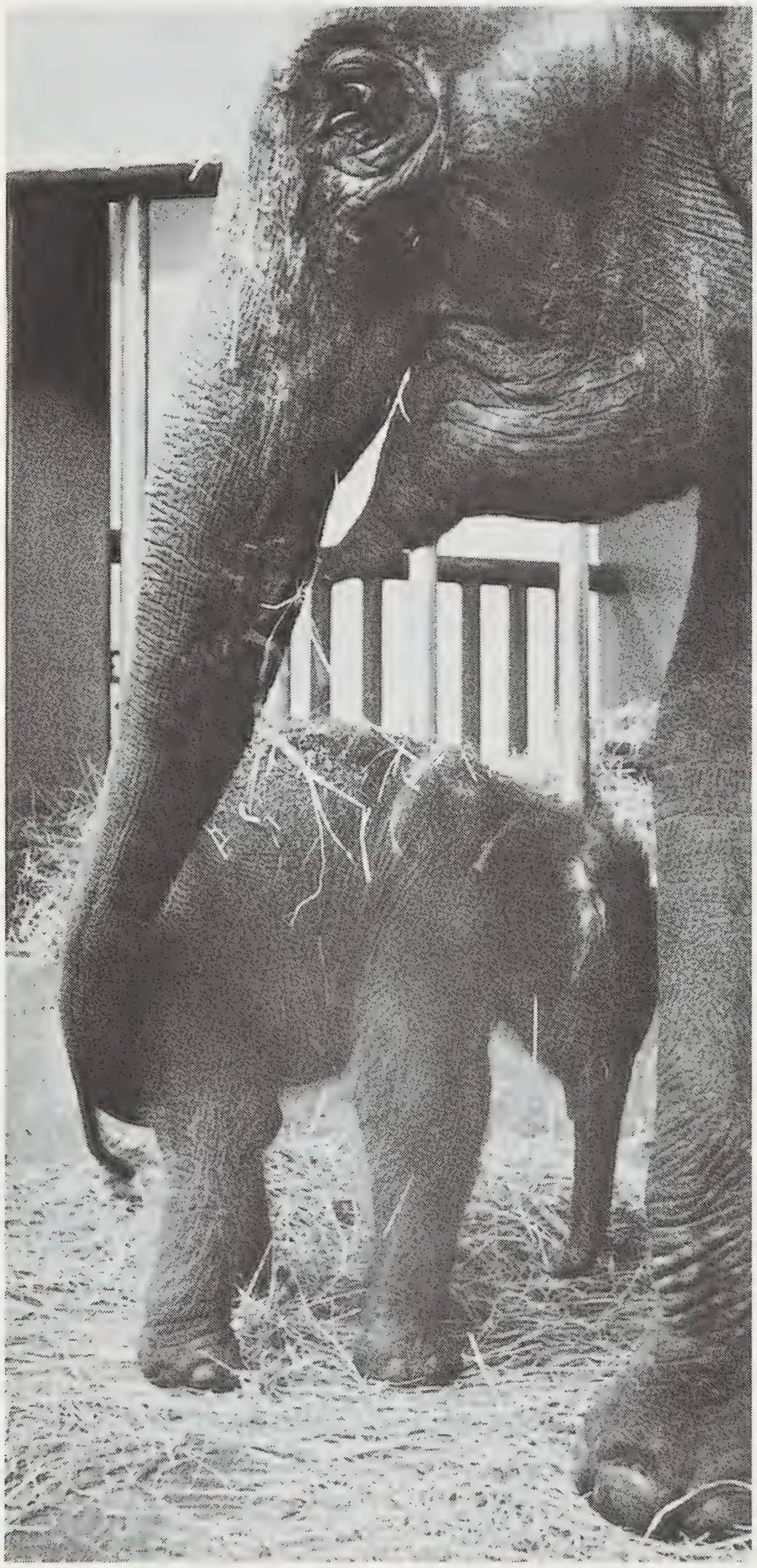
"The most important thing is to allow them to live a coeducational life. As a herd animal they desire constant companionship. The worst thing any zoo can do is separate its elephants for long periods of time.

"Nutrition and a good diet are a must for healthy elephants. We feed our herd such high quality foods as rolled oats, timothy hay, fruit (mostly apples and oranges), and vegetables and greens (mainly carrots and lettuce). We also provide a vitamin-mineral in their grains.

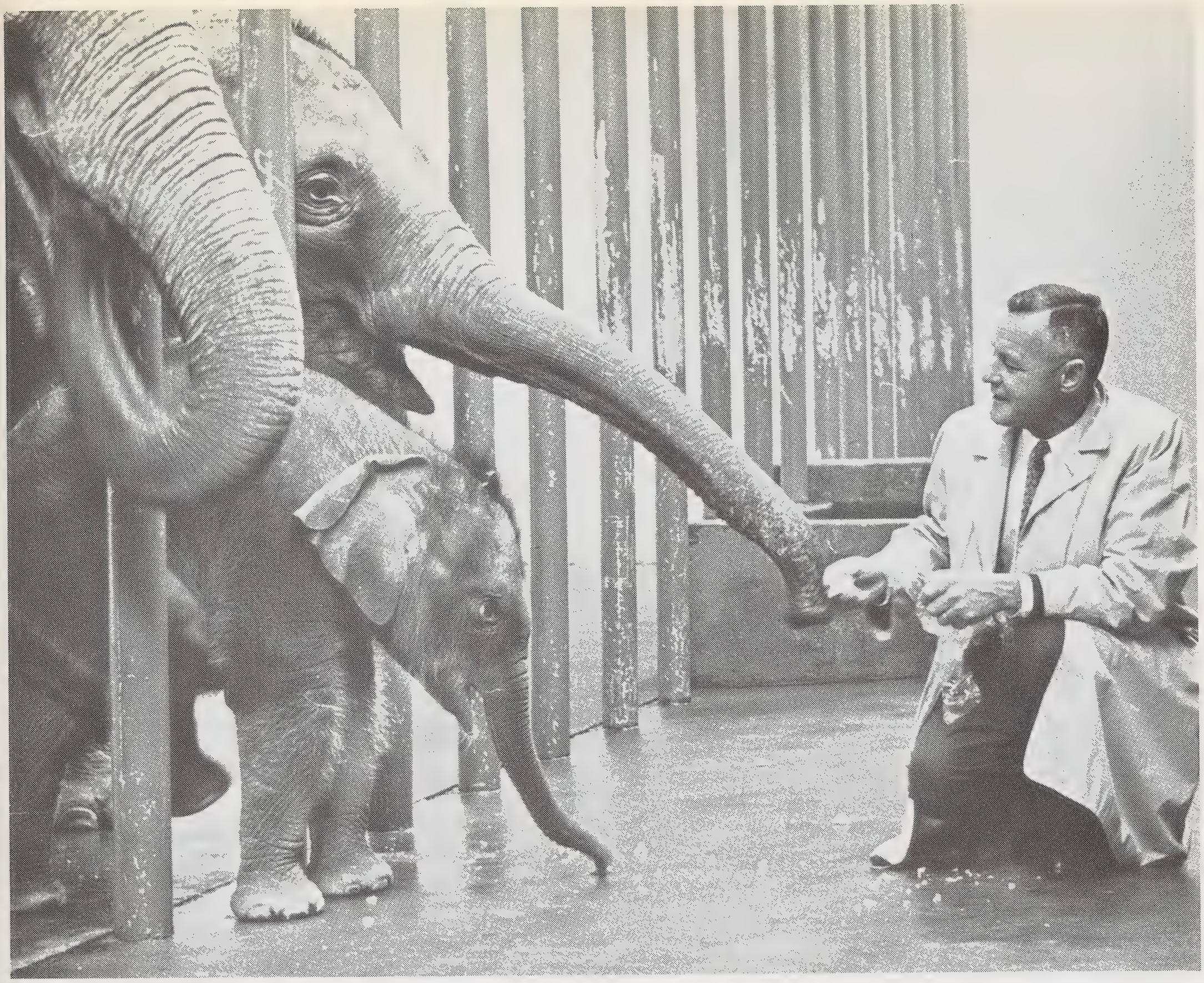
"We provide them with dirt once a week for digestive purposes. They use it to help grind down their foods. And we don't frown on any excess peanuts, popcorn, and other sweets that visitors toss into their compound. It never seems to bother them and being very gregarious by nature, they enjoy all the attention they get from spectators."

Portland's zoo men have found that exercise and constant activity of one kind or another are important to the good health of their elephants. "We encourage their use of the pool and keep training them for their weekend balancing acts," says Dr. Maberry. "We like to see them walking

Belle supports her baby and nudges him to her breasts.



At birth Packy weighed 225 pounds and was 3 feet tall.



Portland Zoo Director Jack Marks, having recovered from the excitement of Packy's birth, feeds bread to the first baby elephant born in the United States in 44 years.

about; when they begin to lie down too often, we worry."

One of the herd's favorite places is their pool. They seem to enjoy the water and are constantly playing in it, often engaging in water-squirting matches.

Elephants are extremely slow to mate, as the female demands a long courtship. "You have to let them get to know each other and be around each other," says Dr. Maberry. "Sometimes it takes up to two or three years. Again, this points up the need of the herding principal, allowing them to be with each other on a consistent basis."

Most of the babies weighed about 180 pounds at birth. Packy weighed in at 225 pounds, and Hanako weighed 240 pounds. The babies generally gain three and one-half pounds a day for the first three months, and weigh between 1,000 pounds and 1,500 pounds at one year of age. On his first birthday, Packy weighed 1,750 pounds—more than his father did at three years when in the wild.

When first born, the babies stand about three feet tall, are the color of mud, and are covered with fuzzy hair usually light in color. They also have a head of black hair with a miniature mustache and beard. The tail is longer than the trunk. Although wobbly in the first hours after birth, the infants usually are walking quite well within a day.

Since the life span of an elephant normally is similar in length to that of humans, the Portland herd is relatively young. Zoo men believe that the four adult females will continue to produce offspring perhaps every two or three years with some degree of regularity. "We should be able to supply babies to other zoos for many years to come," says Dr. Maberry. He feels Portland should keep its own herd at about 10 animals, which he thinks is easiest for handling.

Meanwhile, Portlanders continue to show a strong pride in their elephants and the animals remain the most favored attraction at the zoo. But even the most enthusiastic elephant fans admit they are getting a little blase about all the babies.

This was aptly demonstrated after the birth of Rajah. At that time, the state's largest newspaper, *The Portland Oregonian,* ran a story of the birth on its front page, with the following lead:

"Ho! hum! Another dull day at the Portland Zoo. Just another baby elephant, that's all."

BARNACLES...A STICKY QUESTION

by Vincent R. Liguori

Ever since man first placed a boat in the sea, he has been plagued by barnacles. These tenacious crustaceans only slightly resemble their close relatives—the lobsters, crabs, shrimp, and crayfish. They attach to almost any surface in the ocean and once settled they form a strong and lasting bond. Large encrustations of barnacles often are seen on rocks, pilings, piers, and jettys when the water is low, and on the hulls of ships and boats taken from the water.

Because they grow in dense colonies that form large, irregular masses, barnacles are perhaps the most economically-important of the many organisms which foul marine surfaces. Within eight to ten months, barnacles can grow to a depth of several inches on the hull of a ship. Accumulated barnacle growth makes a vessel heavier and slows its motion through the water. Therefore, the ship's engines must work harder and consume more fuel to move the craft. Moreover, removing a vessel from service to scrape and paint its hull is a costly procedure for the ship owner and for the consumer who makes use of the vessel's services. It has been estimated that in the United States alone, $500 million to $700 million a year are spent on barnacle removal. The individual cost may range from a few dollars to several hundred dollars for small pleasure boats to approximately $100,000 more for large ocean-going liners and freighters. Not counting the cost in the interruption of service to its vessels, the United States Navy pays between $200 million and $300 million each year for barnacle removal. This sort of problem has for years stimulated scientists to investigate the mechanisms of barnacle attachment and to look for measures to prevent fouling by these marine animals.

Research into the problem has led to the formulation of toxic compounds that are incorporated into marine paints. The paints are prepared in such a way that the toxin leaches out, slowly poisoning barnacles that attach to a surface coated with this kind of paint. But this approach, as well as electrical and mechanical methods of barnacle control, so far have failed to provide a completely satisfactory and permanent protection against barnacles.

The problem is sufficiently important to warrant continued study. One of several new research approaches currently in progress is underway at the Osborn Laboratories of Marine Sciences. We believe that a solution to the problem of fouling by barnacles may be found in the study of the cement apparatus of the creatures—the structures in which the barnacle's cement is formed and conducted to hull, piling, jetty, or other surface. Another solution to fouling is sought in the chemical analysis of barnacle cement and in the biochemical steps by which it is manufactured in the tissues. Clarification of these important factors may provide a clue to biological or chemical measures which may be used to block cement formation, thereby eliminating barnacle attachment.

The importance of the anti-fouling aspects of these studies is especially significant, for the natural adhesive secreted by the barnacle also may help solve several medical and dental problems.

Barnacle cement adheres in water. The physical properties of the barnacle adhesive indicate that this biological cement, or a synthetic based on its chemical structure, may be used to bond materials under moist conditions, where conventional cements do not harden, in preformed dental materials, for the temporary attachment of dental braces, and as a cement in the mending of broken bones. In addition, synthetics based on the chemistry of barnacle cement may have potential as underwater bonding agents in the construction of underwater buildings and undersea vehicles.

Little is known about the chemistry of barnacle cement or of the process which enables it to harden or "cure" in an aquatic environment. One reason for this is that it is difficult to collect the cement in pure form in quantities sufficient for a complete chemical analysis. When barnacles are taken from the sea, they already are attached to objects such as rocks, floating debris, plants, or other marine animals. The barnacle's adhesive is set and bonded to the surface on which the animal is glued. The hardened cement is insoluble in common organic solvents such as strong acids and bases, whether these are dilute, concentrated, hot, or cold. Ideally, in order to properly determine the chemical nature of the cement, it should be studied in liquid form, either by dissolving it or by collecting it before it has the opportunity to harden.

We were aware of these problems two years ago when we decided to study the adhesive and the cement mechanism of barnacles. From the onset of the studies, we realized the difficulties involved in obtaining pure cement. Moreover, in the already existing literature, so important to a research scientist, few authors attempted to describe the attachment mechanism in barnacles. Accordingly, our investigations follow several basic approaches, which first included rearing barnacles in the laboratory in large numbers.

Barnacles are hermaphroditic, that is, each animal possesses testes and ovaries. In spite of the presence of male and female sex organs within a single animal, self-fertilization generally does not occur. Instead, the sperm from one animal is transferred to the body cavity of an adjacent barnacle through a long tubular penis. In this way cross-fertilization occurs between adjacent animals.

In the acorn or pyrimidal shaped barnacles, the developing embryos are contained in two sacs which lie in the mantle cavity, an area enclosed by the shells but separate from the major portion of the barnacle's body. These embryo sacs may be removed intact in the laboratory and placed in small aquariums filled with sea water. In one to

Shown above is one of the late naupliar, or larval, stages of the barnacle, *Balanus eburneus.*

Below is the cyprid, the last of six larval stages, during which the free-swimming organism settles on an available surface and finally becomes attached.

Dr. Vincent R. Liguori (at right) examines a barnacle-fouled piece of wood at the Osborn Laboratories of Marine Sciences.

The giant barnacle, *Balanus nubilis* (at far right), was collected from the sea off California; a cold water form, it was originally described by Charles Darwin.

several days free-swimming larvae called nauplii hatch from the eggs enclosed in the embryo sacs. These can be grown in the laboratory under controlled conditions and watched as they progress through their attachment and metamorphosis into the young adult barnacle.

The nauplii are characteristic crustacean larvae. They look like small crabs which have a simple non-segmented body with three pairs of appendages: antennules, antennae, and mandibles. Each nauplius molts six times, growing slightly larger with every molt, while still retaining its characteristic naupliar form. During the naupliar stages the larvae feed on microscopic organisms. In the laboratory we satisfy this food need by providing the nauplii with photosynthetic marine alga, *Cyclotella nana.*

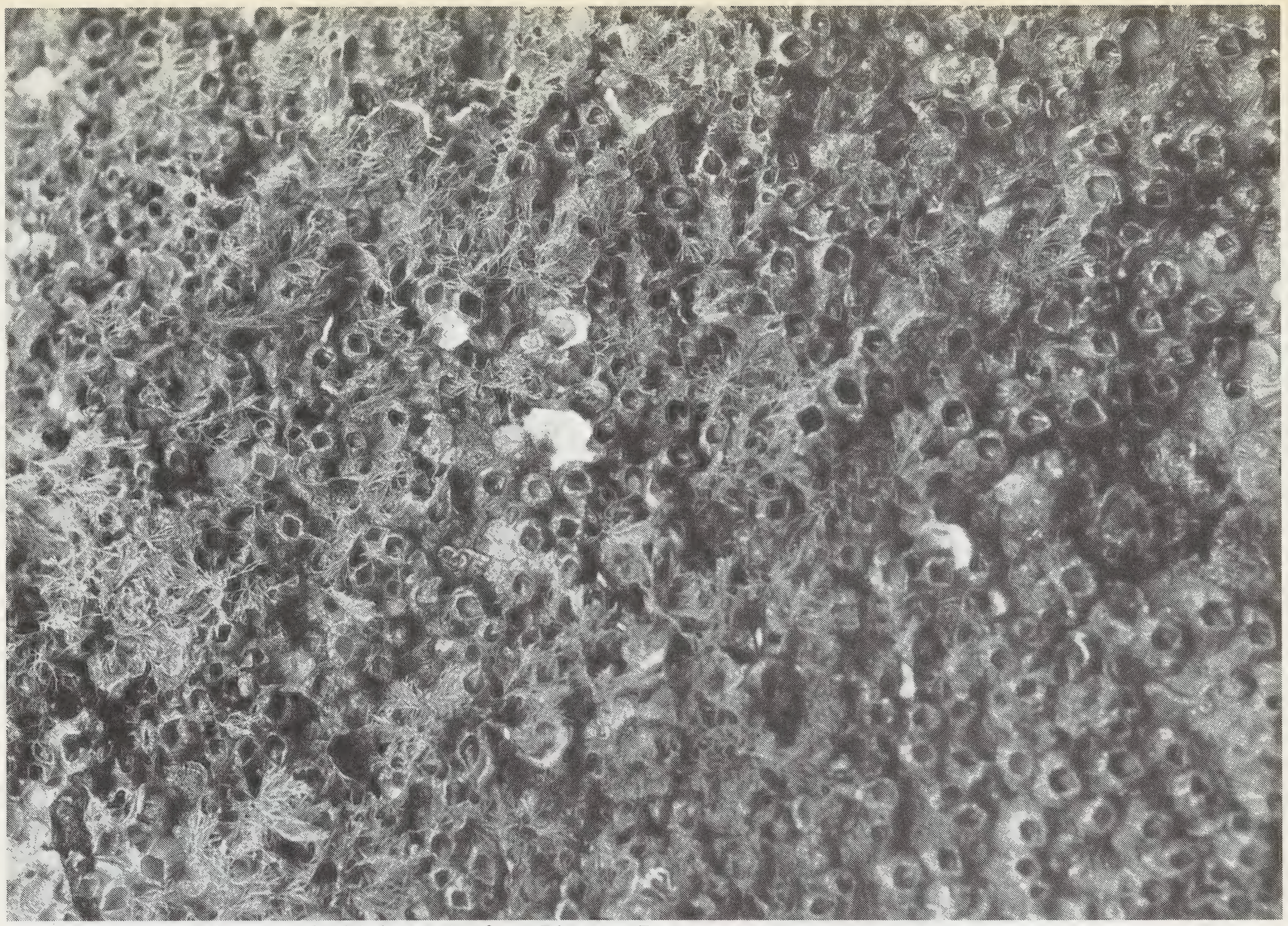
At the final molt, the nauplius changes form. It

becomes a "cyprid," a bean-shaped larva which has two valves or shells. These are arranged on the larval barnacle in a fashion similar to the shells of a clam. The cyprid retains the two small antennae, or "antennules," which it is able to extend and retract into the valves. It now possesses six pairs of thoracic appendages, or "cirri," which look like feathery legs and are used for swimming. At this stage the larvae are non-feeding; they obtain their nutritional needs from fat droplets distributed within their bodies. They swim freely for a length of time that varies with the species, but eventually they settle on an available surface and take up a "walking existence," using the antennules in a bi-pedal movement. Within several hours the "walking" becomes labored. The antennules begin to adhere to the surface. This is the beginning of the attachment process, and at this point, the cement needed for initial attachment is secreted. When the cyprid can no longer free itself from the surface, attachment is accomplished. After several hours, a series of changes occurs within the tissues of the cyprid. These result in the cyprid's metamorphosis into a young adult barnacle permanently glued to the surface on which it has settled.

Cyprids grown in the laboratory are allowed to settle on and attach to surfaces such as paraffin, soft plastic, and paper. The site at which the antennules adhere becomes the junction between cement and substratum. It is studied by preparing thin sections of the organism and the attaching surface. In addition, the tissues which eventually develop into the adult cementing structures are examined in this larval form.

Barnacle anatomy changes remarkably after metamorphosis from the cyprid to the adult.

Therefore, we had to study the barnacle anatomy in order to locate and critically examine the organs and tissues responsible for cement synthesis. For this phase of the study, we referred to the work of Charles Darwin, who in 1851 was the first to report finding cement glands and cement-conducting tubules in barnacles. He properly described the glands as single cells which are round or goblet-shaped and which arise from the cement-conducting tubules. The glands and their tubules are located in close association with the ovaries, and because of this, Darwin erroneously concluded that the glands are modified ovarian tissues. During the late 1800's and early 1900's, other investigators, following Darwin's lead, described the cement glands and canals in additional species of barnacles. The cement apparatus was not completely defined for any one species, but

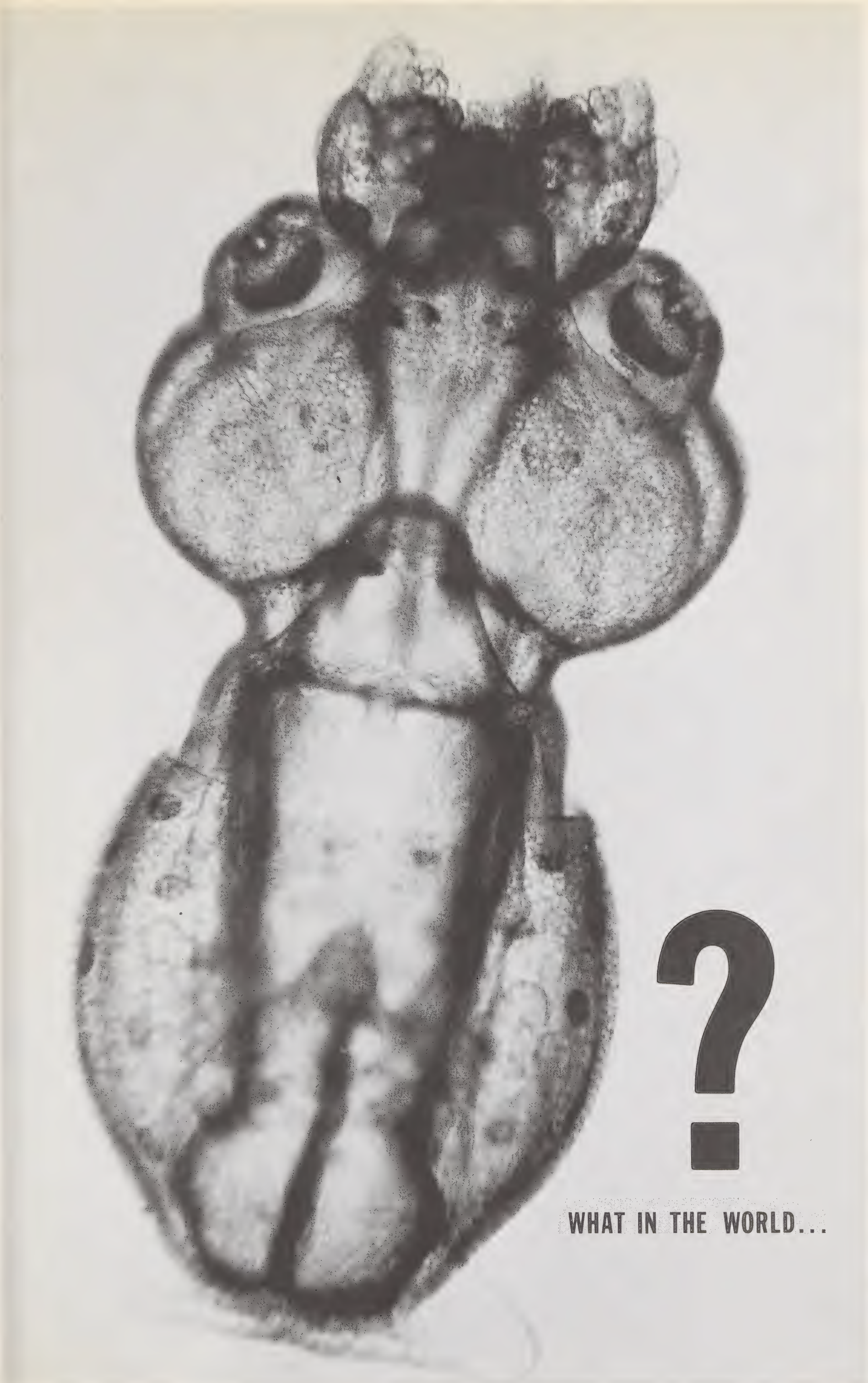


An aluminum plate is covered with barnacles from Biscayne Bay.

the excellent descriptions proved valuable for our studies on the cellular characteristics of the cementing structures of barnacles.

Since the cement glands are located among the ovarian tissues in the species of barnacles we studied, the ovaries were dissected from adult barnacles and prepared for microscopic examination. Basically, in order to examine their cellular characteristics, tissues are studied on glass slides under the microscope. The preserved tissues are prepared so that they may be sectioned into microscopically-thin slices and stained with dyes which enhance specific structures of the cells, such as nuclei or chromosomes. Each cell may be considered a vessel containing chemicals which are able to react with other chemicals in much the same way chemical mixtures react in a test tube. By using this basic technique, it was found that the cement glands are easily discernible from the surrounding ovarian tissues and that their cellular characteristics could be described. In one species of barnacle, a stalked form called *Lepas anatifera,* the "goose barnacle," the cement glands contain many vacuoles in which cement formed at one pole of the cell is transported to the opposite pole and deposited in tubules which penetrate the cytoplasm of the gland. The cement passes through a series of connected tubules or canals, eventually reaching the base of the stalk where it hardens in connection with the attachment surface. The mechanism is slightly different in the acorn barnacle, *Balanus tintinnabulum,* which has a calcareous basal plate making contact with the attachment surface. Cement formed in the glands is not carried in vacuoles, but apparently flows through a filamentous-like cytoplasm from one pole of the cell to the opposite pole, which makes contact with the canal system. The canals leading from the glands connect with the round basal plate where a series of canals are arranged in concentric circles. Cement from the gland cells is conducted to the periphery of the basal plate where it hardens after contact with the surface of attachment.

In spite of the technical advances made in these studies, research on the natural adhesive secreted by barnacles is still in its early stages. We have reached a point in our investigations where we can accumulate the cement in a semi-hardened state, solubilize it, and subject it to initial chemical analysis. However, we must learn not only the chemical nature of the cement—we also must determine the biochemical steps in its synthesis within the gland. In addition, if barnacle cement, or any synthetic chemical similar to it, is to find use in medicine or dentistry, we must know that its use will produce no toxic effect on healthy tissues. Studies to provide the answers to these and other problems related to natural adhesives are currently under investigation.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WHAT IN THE WORLD...

small ant. Many structures prominent on the adult squid are clearly visible in the larvae. The tentacles, not fully developed, are coiled at the anterior end of the creature. The large eyes and numerous spots of pigment, seen here as small dots, are visible. The pigment spots, of many colors, enable the squid to change color in various behavioral situations. The yolk sac of the larval squid is visible in the photograph on the opposite page as a bulbous projection on the young animal.

The larvae pictured here are about ten days old. They were released from the egg chambers by a delicate surgical technique in which scientists punctured the membrane around the egg. Researchers at the Osborn Laboratories are studying the development of a number of marine invertebrates. Besides squid, these include sea urchins, sea stars, sponges, and sea cucumbers.

THE SQUID THROUGH A MICROSCOPE

Photographs by George D. Ruggieri, S.J.

The common squid, *Loligo pealii,* breeds off the northeastern coast of the United States from May through July. Its eggs are held in chambers, which in turn are in capsules. The capsules are clustered and these clusters float in the sea or attach to objects. The egg of the squid – more properly the embryo it holds – is extremely useful in embryological studies. The larval squids shown here were released from egg chambers by surgery during one such study at the Osborn Laboratories of Marine Sciences. These specimens were photographed through a low-power microscrope. The actual size of each larval squid is about that of a

NEW ZEALAND'S RARE BIRDS

Threatened Species Breed at a Mountain Reserve

BY JOHN SIDNEY

"These birds are too tame—we'll have to make things a little more uncomfortable for them," said Colin Roderick, officer-in-charge of the Mt. Bruce Native Bird Reserve, 18 miles from Masterton on the North Island of New Zealand. Three takahes, brilliant blue and large as fat domestic hens, were feeding only five feet from my camera. The male and two females had loose silky plumage; that on the head, neck and breast, abdomen and thighs was indigo in color. The birds' backs, rumps, and upper tail coverts were olive-green; the scapular feathers were peacock-blue changing to metallic sage-green on the mantle. Bright red legs and feet and scarlet beaks completed the picture. Here in a large enclosure of hardwood brush and open space with red tussock grass and flowing water, the Wildlife Branch of the New Zealand Department of Internal Affairs is attempting to breed takahes. Because takahes *(Notornis mantelli hochstetteri)* are flightless, the enclosure is open to the sky.

"We must try to recreate something of the harsh, rigorous conditions of their natural environment," said Colin Roderick. "We're constantly improving the habitat here. Two thousand tussocks of the same species as that growing in the Murchison Mountains (where the last pocket of takahes persists) have been planted here. We plan to plant another 2000 tussocks and to add other natural food sources for the birds."

The site of the 100-acre reserve was carefully selected in 1958 to parallel as closely as possible the natural habitat of the takahes in the Murchison Mountains of the South Island—with the advantages of nearness to veterinary and scientific facilities in Wellington, the capital. The reserve, surrounded by mountains, is a thousand feet above sea level and has a rainfall of 80 to 90 inches a year.

The takahe was thought to be extinct for over 50 years until it was rediscovered in 1948 in Fiordland. There are two to three hundred birds, with an uncertain future at most, in eight primary valleys.

Along with other officers of the Wildlife Branch, Colin Roderick admits to a certain amount of frustration. The takahes at Mt. Bruce are healthy, and during each of the last four years the birds have built good nests, displayed and postured, and laid a total of 16 eggs—all infertile. The fertility of the male bird, Paul, is at least suspect. Another male bird, which died a couple of years ago at the age of six years and eight months, was found to be infertile—an expert said that sperm formation had not occurred and probably never had.

The transfer of the first four takahe chicks to Mt. Bruce in November 1958, to be reared by bantam foster mothers, stirred up a fierce controversy among New Zealand conservationists. Some said they hoped "the birds would be left in peace and allowed to work out their destiny without disturbance." But others urged the more positive approach of breeding in captivity. There's much to be advanced for this view. Imported deer have found their way into Takahe Valley, cannot be completely kept out, and must affect the habitat. Moreover, stoats, also introduced into New Zealand from Europe in the past, have begun to appear and have taken some birds. In addition, there are the hazards of a high fire danger in dry

Among the birds successfully bred at Mt. Bruce (shown below) is the yellow-crowned parakeet (opposite).

The takahe, thought to be extinct for over 50 years, was rediscovered in 1948. Its continued survival may depend on the attempts to breed the flightless bird on the reserve.

weather and the bitter winters of Fiordland. For instance, no chick survived the 1963/64 breeding season, when the winter was particularly severe and prolonged. Also, as Brian Reid of the Wildlife Branch points out, it is possible to remove chicks and raise them elsewhere without materially affecting the population in Takahe Valley. "History records and observations on banded birds show that 40 to 50 percent of chicks die in their first year and that only 30 to 40 percent of those hatched reach breeding age," he said. "Moreover, the hierarchy and territorial claims probably prevent young birds who survive the first two years from breeding, because there is no niche within the social order until the deaths of some older birds. Their reproductive capacity may, therefore, remain unused for a wasteful number of years."

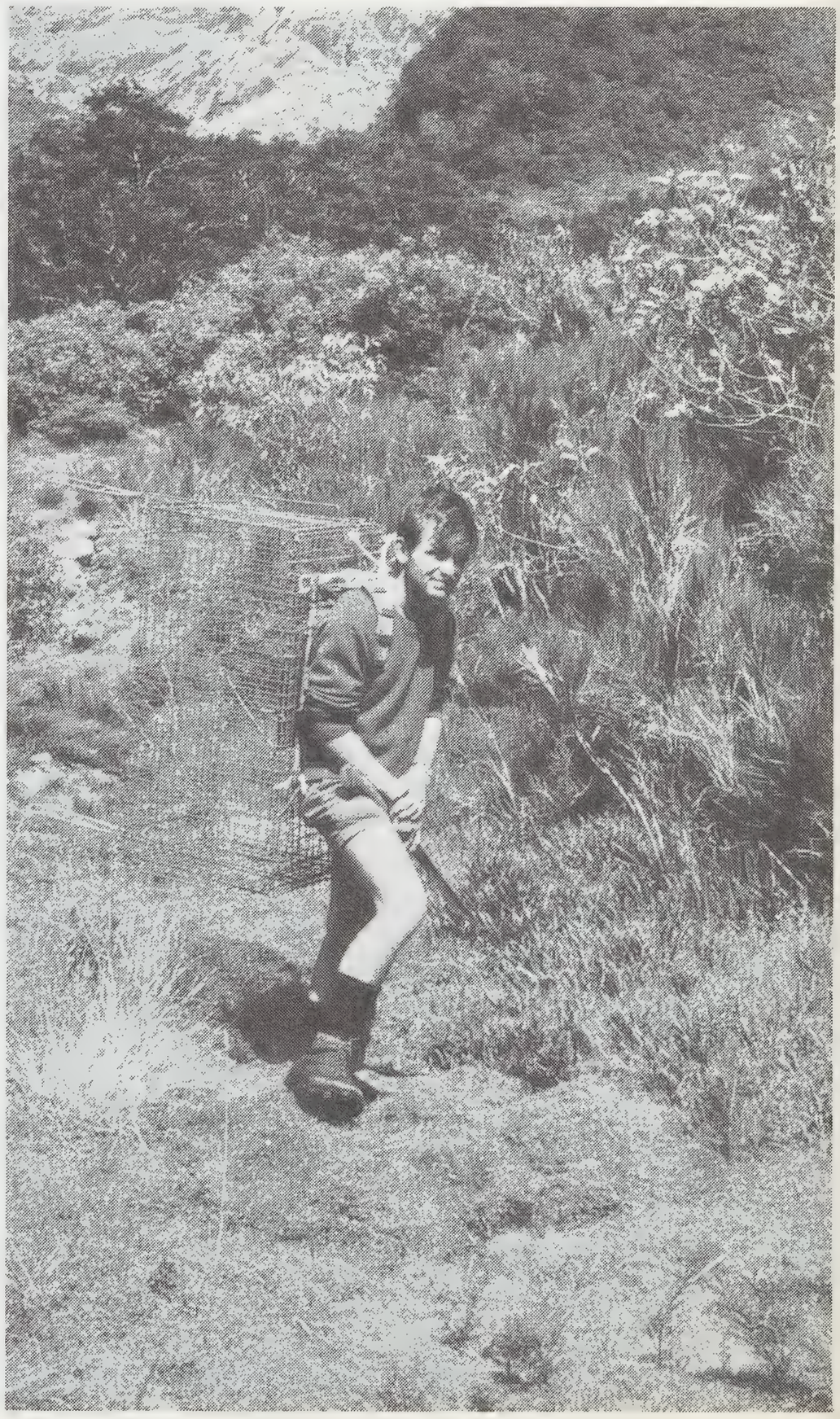
Mr. Reid, who has done field work in Takahe Valley, added that another possible solution is to remove adults and thus provide space and status for the younger birds within the population. "If individual bird and territory history are known, both chicks and adults can be removed without reduction in the size or genetic variability of the population," he said.

The attempt at breeding at Mt. Bruce has involved only four adults and three chicks. Some have died, but probably would have done so in any case if left in Takahe Valley. Their life span at Mt. Bruce has been as good as that in the wild, and captive chicks do very much better than wild young. As well as feeding naturally, the birds' diet is supplemented with measured amounts of a suitably constituted mash, which ensures that essential minerals, trace elements, and vitamins are available. Controlled doses of antibiotics are given in the mash when necessary.

The experiment with the takahes led to the decision in 1960 to develop the reserve with the threefold purpose of breeding, scientific study, and display of rare and threatened New Zealand birds. In a comparatively short time of six years, the reserve has had notable successes with the breeding of North Island saddlebacks, the blue duck, the yellow-crowned parakeet, and the red-crowned parakeet.

The North Island saddleback *(Philesturnus carunculatus refusater)* was broadly distributed over the whole island in the last century, but is now believed to be confined only to Hen Island of

Colin Roderick, officer-in-charge of the reserve, packs a trap into Tutoko Valley.



The North Island saddleback was once broadly distributed over the whole island. Continued successful breeding of the species will enable the reserve to release birds in suitable areas.

the Hen and Chickens Group where it is found over an area of about a thousand acres. The future of this 10-inch-long bird, bright yellow with a glossy black back, depends on the island remaining unchanged. At present the only mammal there is the Polynesian rat *(Rattus exulans).*

Colin Roderick has had his successes with saddlebacks. They normally lay a clutch of two to three eggs, with sometimes a second clutch. By giving them an optimum diet in an experiment in the 1965 season, the birds were able to lay nine eggs in the breeding season. Seven hatched successfully—two eggs were taken by rats. The reserve plans to build up its population to release the saddlebacks in suitable areas.

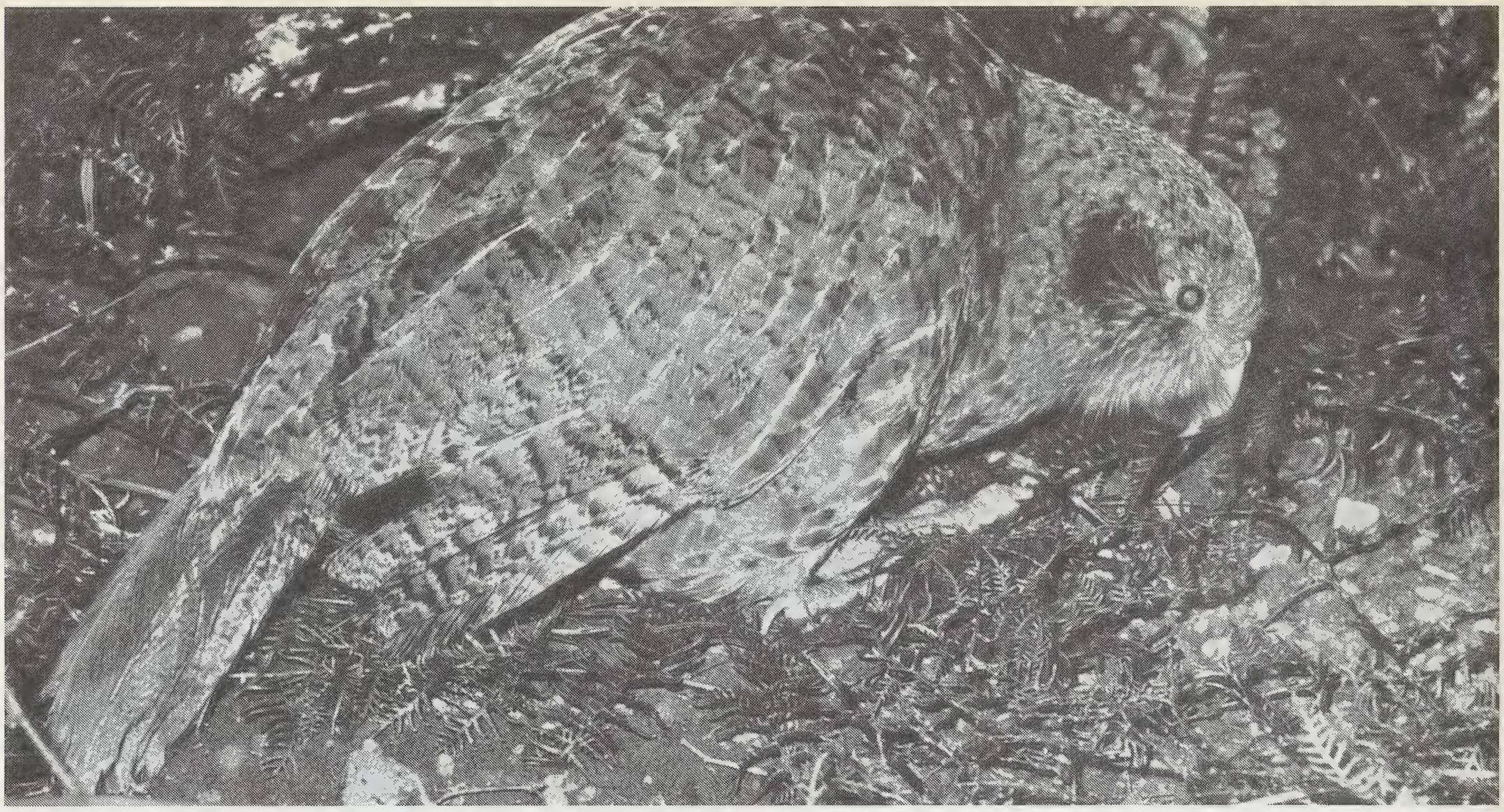
The blue duck *(Hymenolaimus malacorhynchos)* is today restricted to the more remote forested mountain areas. This slaty-blue bird with a chestnut red breast is probably one of the most ancient inhabitants of New Zealand. Jean Delacour and Peter Scott in *Waterfowl of the World* point out, "The curious blue duck of New Zealand mountain streams is one of the most puzzling of all waterfowl as to its affinity with other species . . . it has no obvious similarity to any other ducks . . . Its habits and behaviour, although not well known, are certainly quite special." In a trip to New Zealand a few years ago, Peter Scott regarded the sighting of a blue duck family in Takahe Valley as the highlight of his visit and ample compensation for failing to see a takahe.

The pond is being developed at Mt. Bruce to provide habitat for the breeding of other New Zealand waterfowl whose numbers are diminishing.

Mt. Bruce has had such success with breeding the yellow-crowned parakeet *(Cyanorhamphus novaezelandiae)* and the red-crowned parakeet *(C. auriceps)* that large releases have now been made in areas favorable to their survival.

Mt. Bruce, too, has been successful in breeding the North Island race of wekas *(Gallirallus australis),* brown-colored members of the rail family, and releasing them in suitable areas. These birds, about the size of domestic hens, and with a rich brown plumage streaked with black, were once widely dispersed over the North Island but are much reduced today. The populations of the three South Island races, although reduced since the last century, are holding. Wekas are pugnacious, energetic birds and can re-establish themselves given a reasonable chance.

The reserve has also been successful in breeding the pied fantail *(Rhipidura flabellifera)* and the rifleman *(Acanthisitta chloris),* two other rare birds. There are future plans to breed the even rarer stitchbird *(Notiomystis cincta).* Stitchbirds were once fairly widespread on the North Island



Breeding of the kakapo has been suspended at Mt. Bruce until more is known of its ecology.

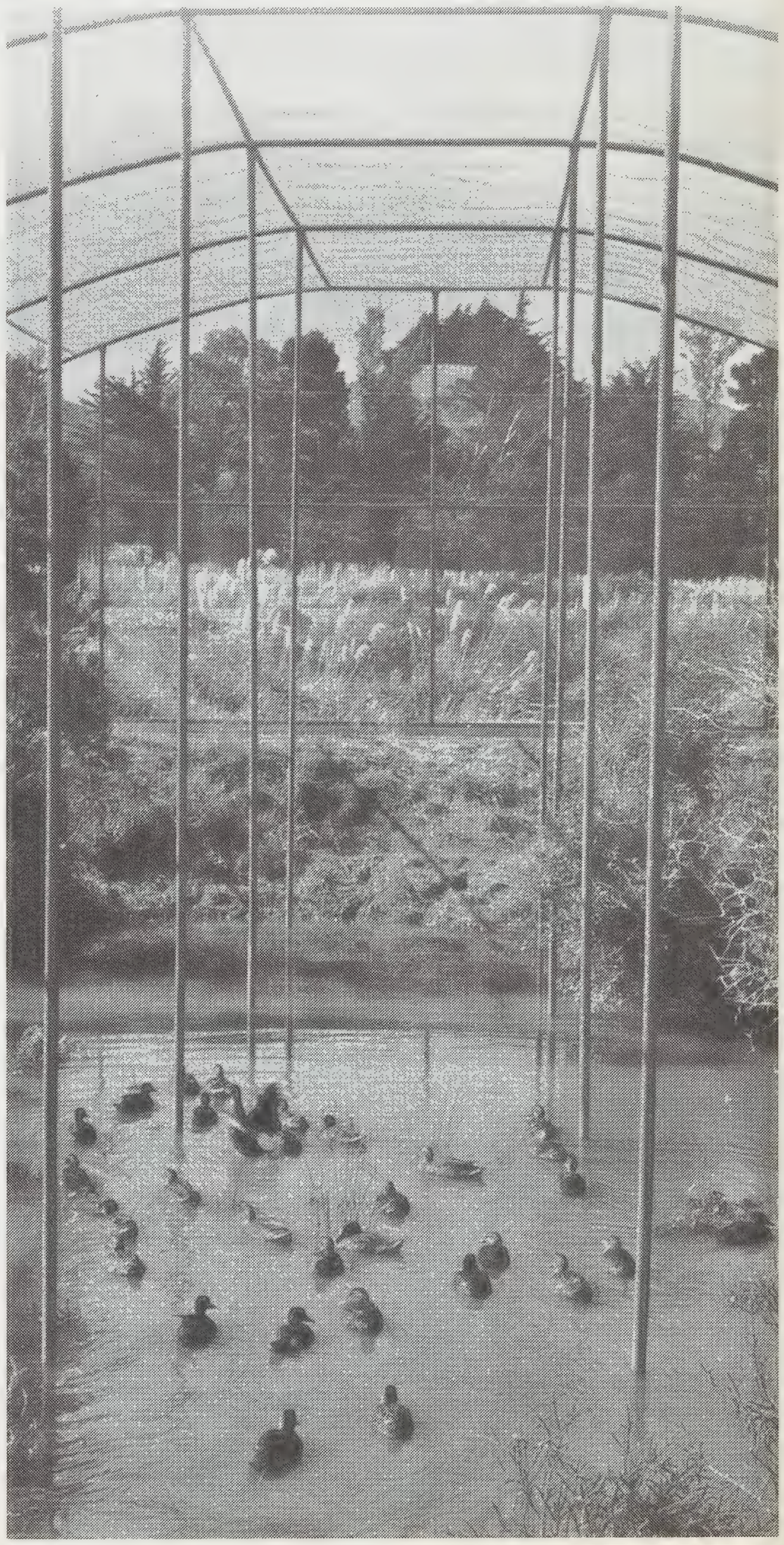
mainland and the Great Barrier Islands, but are now regarded as extinct except on Little Barrier Island in Hauraki Gulf. (There have been unconfirmed reports of them occurring in the Ruahine Ranges.) The reserve plans to breed the North Island blue wattled crow, another threatened species.

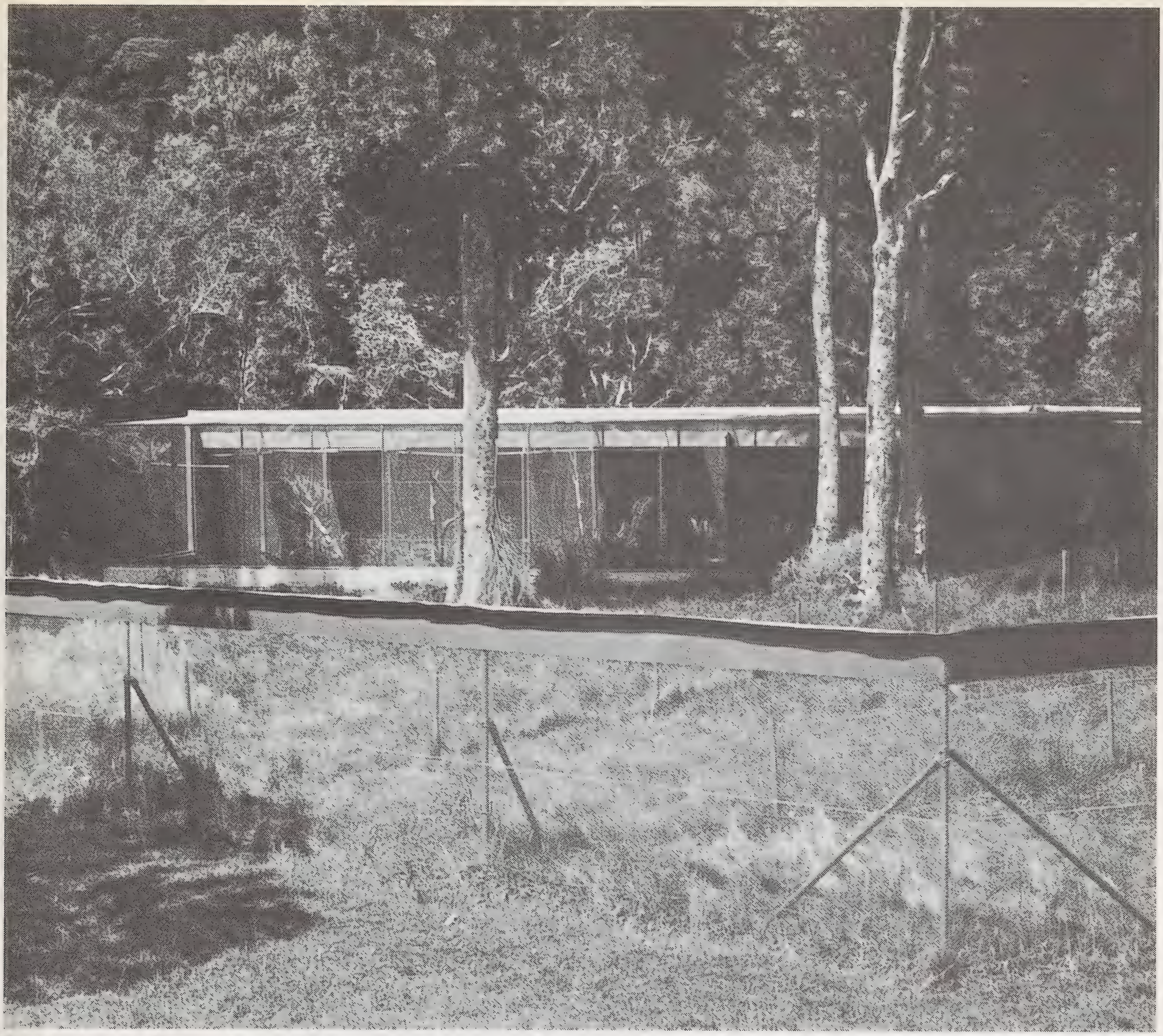
As a display center where people, including overseas ornithologists, can see something of the unusual and often unique birds of New Zealand in near-natural surroundings, the reserve has been an unqualified success. The average New Zealander today sees few native birds in the settled areas, where mainly introduced birds have taken over.

Mt. Bruce has suspended attempts to breed kakapos *(Strigops habroptilus),* those large green, almost flightless parrots of the southern alpine forests, until more is known about their ecology. During January and February 1961, five kakapo were moved there; four died shortly afterward. This was not a total loss because post mortems allowed scientists to learn of infections present and of those that might be lethal. This knowledge guided Mt. Bruce in keeping the solitary survivor in good health for nearly four and a half years. (An autopsy suggested that it probably died of old age.) During its stay the bird was studied closely at night under red lights, of which the bird was not aware.

The kakapos are probably in even graver danger than the takahes. Destruction of the habitat by settlement—four-fifths of the forests have been cleared—has affected the kakapos severely. They were once on both main islands. Today they are gone from the North Island—there have been no reliable reports there for 30 years. Small pockets

Below is the complete duck aviary at the reserve.





The avaries at Mt. Bruce enable visitors to see something of the unusual and often unique birds of New Zealand in near-natural surroundings. The average New Zealander today sees few native birds in settled areas, where mainly introduced birds have taken over.

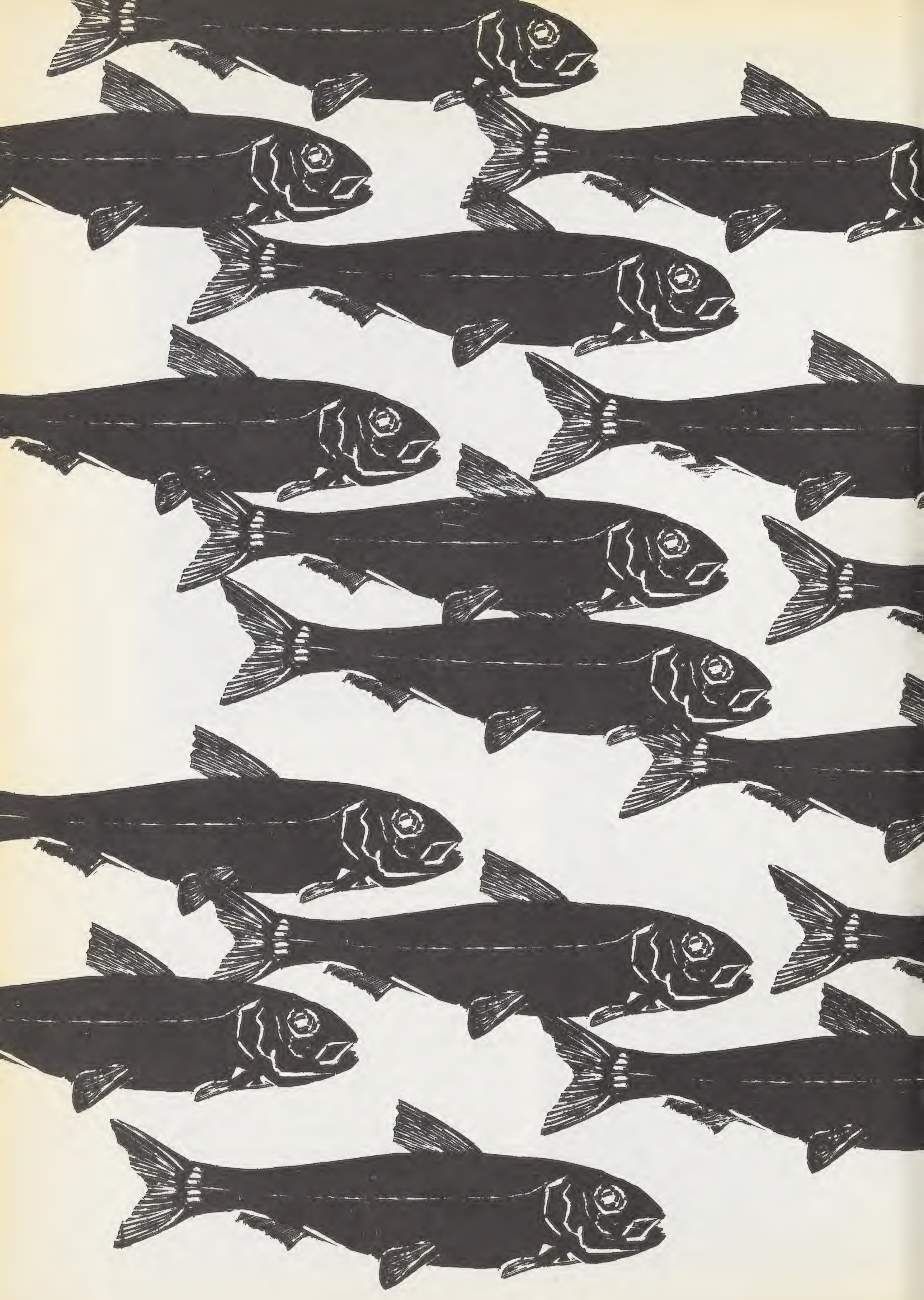
exist in Fiordland on the South Island.

"For practical purposes the kakapo is a dead species in all but Fiordland," Brian Reid told me. He said a few survivors may exist elswehere but were doomed. The only hope is that there are enough small population pockets in parts of Fiordland to enable the bird to be saved.

Between March 1958 and February 1965, the Wildlife Branch sent 25 expeditions in search of kakapos. The degree of effort involved is underlined by the fact that this was equal to one man spending a continuous 4.6 years in reaching and covering possible areas. These trips were made in miserable conditions in some of the roughest, most formidable, and wettest country in the world. The difficulties of observing kakapos in dense beech forests clothing the lower slopes of ranges with a 300-inch rainfall may be gauged by the fact that over a period of 10 years one Wildlife officer saw birds on only two occasions. In terrain like this, it is impossible to keep a bird in sight for more than a few feet. In rugged Fiordland the pockets of kakapos face the same threats as the takahes.

Two courses are possible. One is to liberate some birds on sanctuary islands. But this would not necessarily be successful. Two attempts in the past to introduce them to Kapiti Island and to Little Barrier Island failed. The other course is to breed them in captivity.

As a footnote to a memorable day at Mt. Bruce, Colin Roderick showed me one of the world's rarest birds and one which only a handful of people have seen. This was the quail-sized, flightless Auckland Islands rail. The solitary bird I saw was only the third ever observed for science. The previous one had been seen in 1894 and the species was thought to be extinct. The tiny, swift-running, red-brown bird was caught early in 1966 in the uninhabited sub-antarctic Auckland Islands Group, 300 miles to the south of New Zealand. The recent expedition saw one only—on Adams Island. The bird has always been rare.



The Alewife Invasion

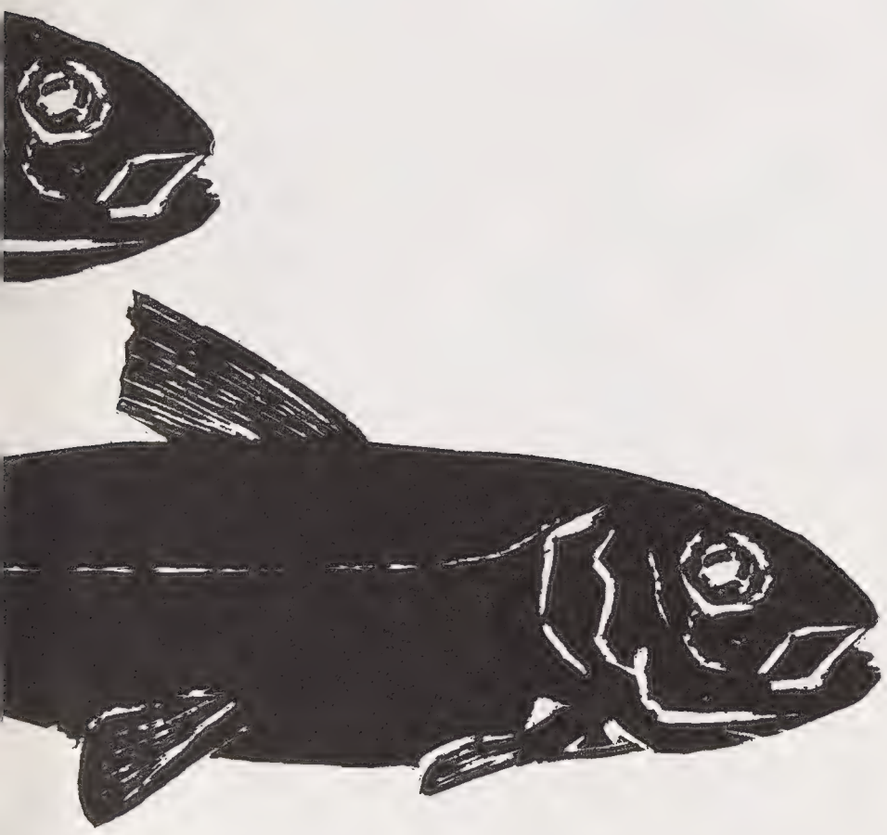
by George Leposky

Federal officials are warning cities on Lake Michigan that 1970 may bring another onslaught of alewives, the small silvery relatives of the herring, which died in the lake by the millions in 1967, clogging municipal water intakes and piling up to rot on the beaches.

The U.S. Bureau of Commercial Fisheries, which uses research boats with trawling nets to catch alewives for sample survey purposes, discovered last fall that a large number of young alewives hatched in 1968.

"It takes about two years for them to get to the size at which they die off," said M. R. Greenwood of the bureau's office in Ann Arbor, Michigan. "We expect some increase by 1970, but it shouldn't be as disastrous or troublesome as in 1967."

That was the year Chicago spent nearly a quarter of a million dollars—about $4,500 a day through much of the summer—to clear its beaches of dead alewives. In Gary, Indiana, the cost was $75,000, and similar sums were spent by other cities around the lake. Factories were shut down when dead fish drawn through water intake pipes clogged machinery. Owners of summer homes near the shore were driven away by the odor of decomposing alewives, and the West Michigan Tourist Association estimated that resort owners lost more than $50 million worth of business.

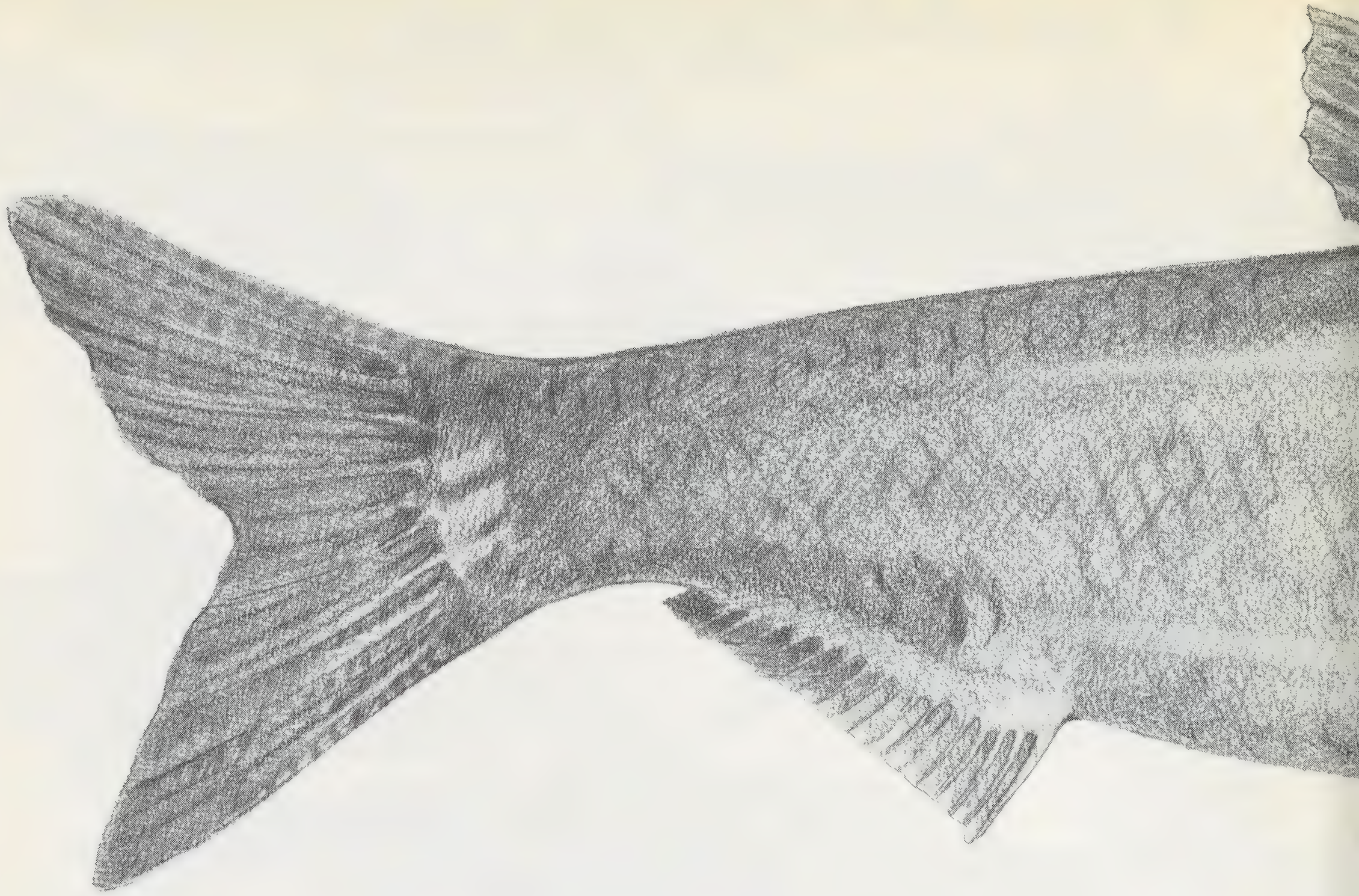


Most residents around the Lake Michigan shore perceived the "alewife problem" only in terms of personal inconvenience and financial loss. Most scientists, however, view the disruptions of human activity caused by dead alewives as symptoms of a far greater problem: man's disruption of Lake Michigan's ecology.

H. William Newman, assistant chief of the bureau's Inland Fisheries Branch, notes that intensive market fishing had already changed the balance among native species of fish in Lake Michigan by the time the Welland Canal between Lake Erie and Ontario was opened in 1932.

The canal allowed ocean-going ships to bypass Niagara Falls and penetrate to the upper lakes. It also allowed the sea lamprey and the alewife, fish species native to Atlantic coastal waters, to invade Lake Michigan, where they caused gross disruption of the fish species balance.

First the sea lamprey, which attaches to the bodies of other fish and sucks out their juices, decimated the lake trout and burbot populations



in the 1940's and 1950's. The victims were the primary predators in Lake Michigan.

The alewife was first recorded in the lake in 1949. With the lake trout and burbot populations decreased, it found few predators there to threaten its prosperity. Its numbers swelled virtually unchecked, and as the alewives enacted the various stages of their life cycle, they came to dominate practically every piscine niche in Lake Michigan.

In the winter alewives gather in deeper, warmer water where they compete with the whitefish for living space and food—primarily the small aquatic organisms known collectively as zooplankton.

In late winter and early spring, the alewives move toward shore through a region occupied by a species of chub, the bloater. In June and July they spawn in shallow onshore waters, crowding out lake herring, emerald shiner, and yellow perch. Young alewives occupy middle depths, competing with the young of chubs, lake herring, and smelt.

All of these other species have decreased in number in Lake Michigan during the 1960's.

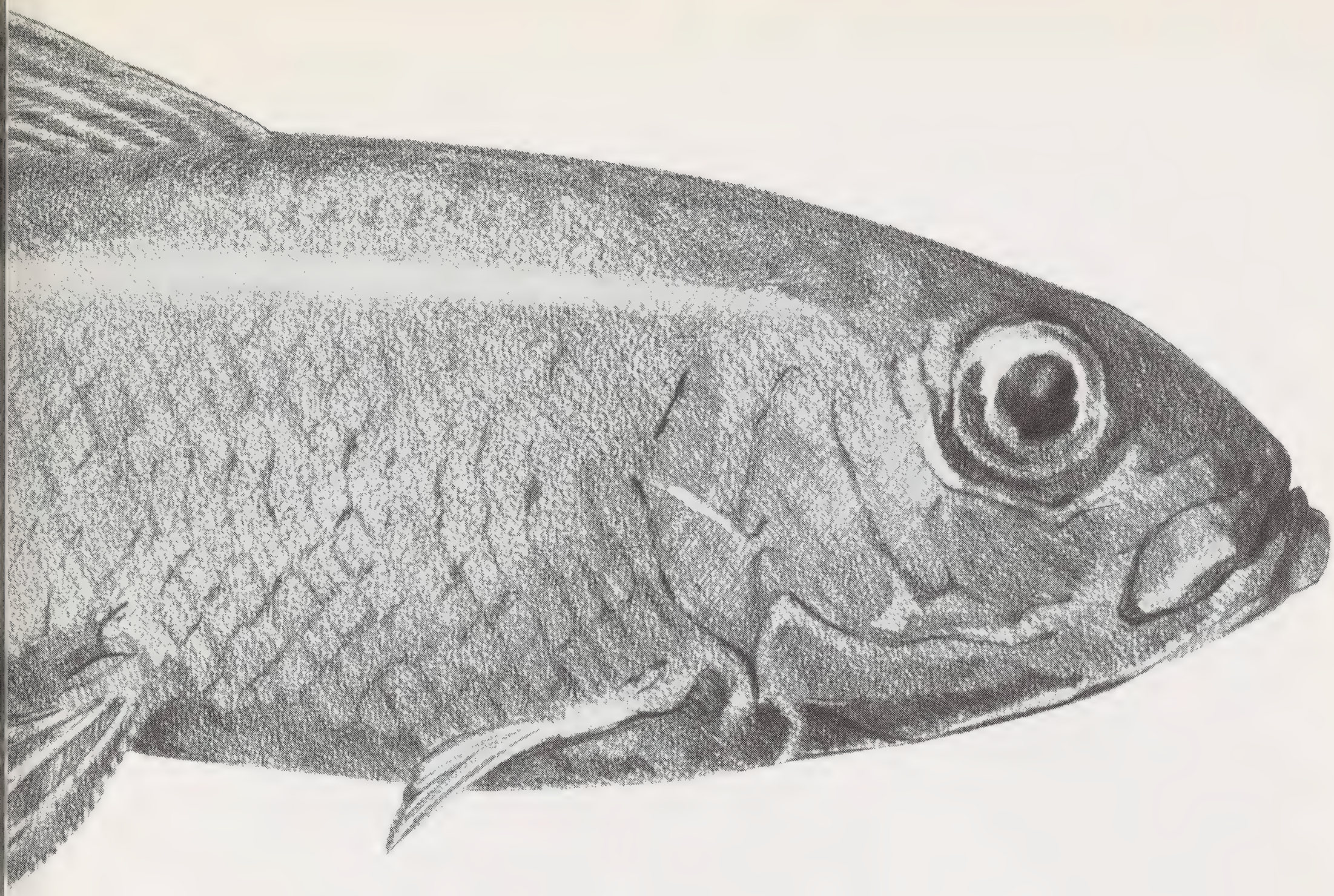
Newman estimates that today about 90 percent of all fish in Lake Michigan, by weight, are alewives. Yet despite this apparent success as a species, the individual fresh-water alewife has a shorter life expectancy and lower reproductive rate than the marine form.

In their native waters off the New England coast, the alewives are anadromous—they live most of their lives in salt water, but ascend fresh-water streams to spawn, as do ocean salmon. The marine alewives are from 10 to 13 inches long at maturity, live five to eight years, and many individuals spawn twice.

In Lake Michigan few alewives reach a length greater than eight inches. Most live only three years and spawn only once. Marine forms produce 60,000 to 100,000 eggs, while fresh-water alewives produce only 11,000 to 22,000. The marine alewives do not suffer from the massive mortalities which occur in the Great Lakes.

The reason—or reasons—for these dieoffs is not fully understood. Zoologist Carroll R. Norden of the University of Wisconsin at Milwaukee places the blame on a "combination of environmental conditions to which the alewife is most susceptible, and the inner mechanism of the fish which fails to cope with this physiological stress. The seasonal nature of the phenomenon suggests that the endocrine system is involved."

Loren P. Woods, curator of fishes at Chicago's Field Museum of Natural History, contends the fish develop a thyroid condition because they are imperfectly adapted to living their entire lives in fresh water. In salt water, he explains, the thyroid



gland aids the alewives in discharging water which enters their bodies by osmosis through cell walls. The body fluids of the fish are saline, and an effective chemical balance is maintained between the fish and their home waters.

In fresh water the osmotic balance is tipped. More water enters the fishes' bodies, and the thyroid strains to keep them from "drowning" in the water. An additional factor leading to thyroid exhaustion is the low iodine content of the Great Lakes; the thyroid does not receive sufficient amounts of this element so necessary for its proper functioning.

Bureau of Commercial Fisheries research reports indicate the thyroid gland also helps the fish adjust to temperature changes in the water. An exhausted thyroid leaves the Lake Michigan alewives more vulnerable to shock when they move in the spring from the open lake to the warmer onshore shallows where they spawn. At any rate, the fish are more fragile then due to endocrine activity. A combination of factors overstresses their systems, and they die.

Researchers do not know precisely what these factors are, or how to measure them. With this knowledge, they could hope to predict when and where a massive alewife mortality will occur.

In the years since 1956, when Lake Michigan's alewife "population explosion" really began, more and more dead fish were present each summer, leading up to the 1967 catastrophe. Then the states sought federal aid, and the Department of the Interior responded by assigning a task force, which made recommendations for alewife research and control programs to cost about $11.4 million by 1973.

To provide more immediate relief, the department's Federal Water Pollution Control Administration offered $250,000 in matching funds to hire 16 commercial trawlers, which would skim dead alewives from the lake's surface. The four lake states—Illinois, Indiana, Michigan, and Wisconsin—together contributed a like amount, and the trawlers began operating in June, 1968. They found relatively few dead alewives. The fleet was trimmed to eight boats before the end of July, and nets and other equipment purchased for the operation have been turned over to the states.

The reasons for the relatively light 1968 mortality remain unclear. It is possible that the combination of physiological and environmental factors was especially favorable to alewife survival, just as it may have been especially unfavorable in 1967.

It is also possible that the Lake Michigan alewives are developing a cycle of periodic oscilla-

tions in population size similar to those experienced by lemmings or snowshoe hares, in which the animals increase to numbers at which they appear to exhaust the carrying capacity of their environment, then go into a precipitate decline, slowly rebuild their numbers to peak levels, and repeat the cycle again. For the snowshoe hare the cycle is repeated every nine or ten years. The unusual presence of large numbers of dead yearling fish among the alewife corpses in 1967 tends to strengthen this hypothesis, but alewives in large numbers have not inhabited Lake Michigan long enough for the hypothesis to be confirmed or denied by observation.

Mr. Greenwood believes that alewives are being held in check by "competition among themselves, and an increase in predators." These are the lake trout, and Chinook and coho salmon, large numbers of which have been released in Lake Michigan in recent years.

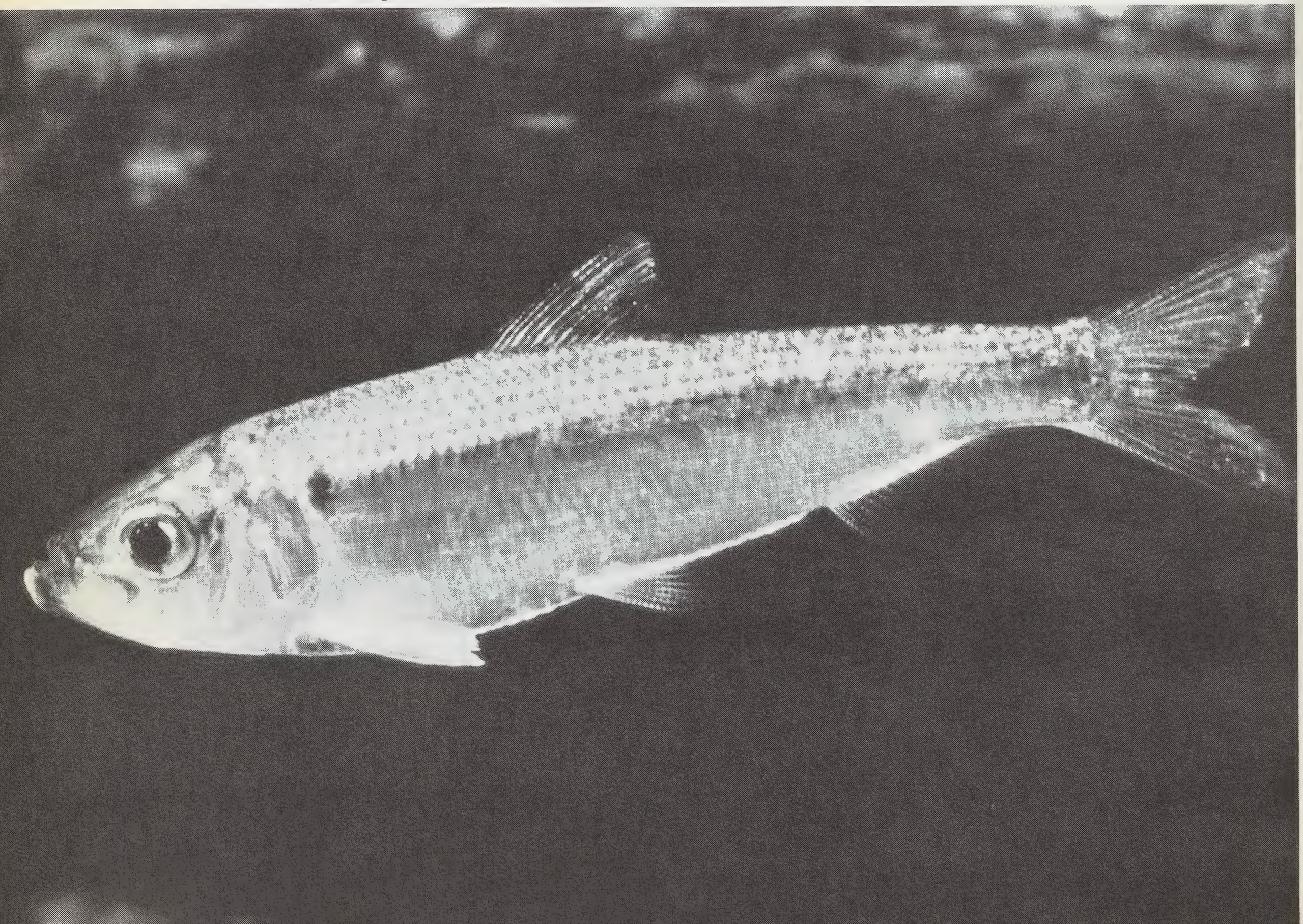
Chemicals to control the lamprey were developed in the late 1950's, at which time the lake trout were close to extinction. Since 1965, almost 7.3 million trout have been restocked in Lake Michigan in a cooperative program involving the federal government and the four lake stages. Michigan maintains a brood stock at its Marquette hatchery, and the eggs are reared by the U.S. Bureau of Sport Fisheries and Wildlife in a hatchery at Jordan River, Michigan.

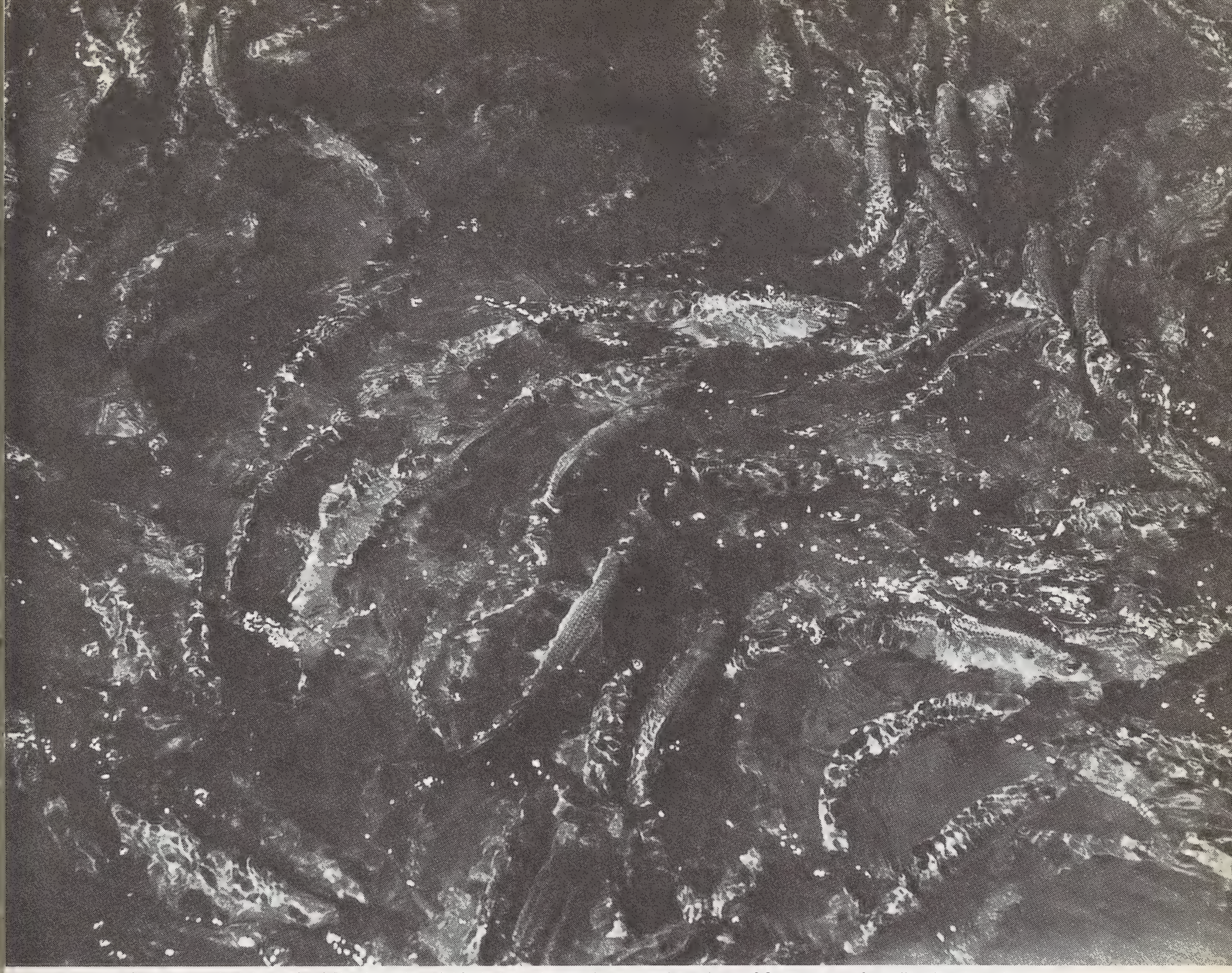
Over 3.56 million cohos and 1.48 million Chinooks have been stocked in the lake since 1966 by the state of Michigan. These are reared in hatcheries, from eggs supplied by the fisheries departments of Oregon and Washington. Survival rates equal or surpass the success of these fish in their native habitat, according to Robert W. Saalfeld, assistant executive secretary of the Great Lakes Fishery Commission in Ann Arbor.

A major commercial and recreation fishery has developed around these salmon and lake trout, an indirect benefit of the alewife control effort. Mr. Saalfeld said analysis of the stomach contents of captured trout and salmon indicates that "the alewife becomes the dominant item of their food diet as they grow beyond one foot in length. Clearly they're having an effect on the alewife population."

The Bureau of Commercial Fisheries is trying to encourage commercial fishing for alewives as a more direct control measure. In 1967, 42 million pounds of live alewives were netted in the lake, and the bureau believes a 200 million pound annual fishery can be developed. About 80 percent

The alewife, a fish species native to the Atlantic coastal waters, is related to the herring.





Alewives were first recorded in Lake Michigan in 1949; it is estimated that today about 90 percent of all fish in the lake, by weight, are alewives.

of the 1967 catch was processed into fish meal for feeding to chickens and livestock, while the other 20 percent went into pet food. In 1968, prices for these products dropped because the market was glutted. The owners of the 16 trawlers involved in the federal-state cleanup project agreed to participate because they were guaranteed operating expenses for their boats even though they were picking up dead fish—valueless garbage.

Other problems facing this industry are odor, water pollution, and competition from other types of animal food. Recycling of air from a commercial plant's drying equipment can be engineered to control odor, and standard air pollution control devices can be employed. Liquid effluent which decomposes and pollutes water can be condensed, and the dissolved fish protein it contains can be recovered by spraying the condensate onto fish meal in the drier.

Unfortunately, the industry is a marginal one, with the difference between profit and loss prices for the products as little as two cents per pound. Pollution control measures can be expensive enough to price the products out of the market.

Fish meal plants were built in Milwaukee and Sturgeon Bay, Wisconsin, in 1964. The Sturgeon Bay plant has closed, and the Milwaukee plant has had continuing problems with odors. Other plants have been operating with varied success near Peshtigo Point, Wisconsin, and Menominee, Michigan, and a pet food plant has opened near Saugatuck, Michigan. Researchers seeking other commercial uses for live-caught alewives suggest that processing them into fertilizer appears promising.

Because the alewife is a benefit in Lake Michigan as well as a curse, no real effort is being made to eradicate the species from the lake. Instead, the Interior Department task force recommended a variety of research programs aimed at restoring ecological balance and improving methods for harvesting the lake's fish resources. "Our long-range goal," Mr. Greenwood said, is the establishment of a better balance between species in the lake. This in itself constitutes a control of alewives."

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

The Year of the Alligator

New York, N.Y. – With the stroke of a pen, a battle in the alligator war was won when Mayor John V. Lindsay signed a law on December 29, 1969, banning the sale of alligator products in New York City. The law, which goes into effect as of January 1, 1970, had been introduced to the City Council by Councilman Robert A. Low. Violators are subject to a year in prison or $1,000 fine and confiscation of merchandise. Stores have until July 1, 1970, to dispose of their present stock.

This was a fitting ending for a year which saw the growth of public concern over the fate of the American alligator. The American alligator is a species unique to the United States, and it is protected in every state where it occurs naturally. Perhaps the best known home of the alligator is Everglades National Park. But even there, protected by park rangers, the alligators have not been safe from poachers. Poachers could make enough money in one night of their grizzly work to pay for the fine the local courts might impose should they be caught.

The alligator's survival should also be helped by the endangered species bill which was signed into federal law by President Nixon on December 5, 1969. This law prohibits the interstate shipment of alligators and hides. Nevertheless, conservationists hope that other major cities across the country will follow New York City's lead and enact similar laws on the sale of the finished products.

As part of the continuing struggle for the preservation of the American alligator, the American Alligator Council, an organization formed in 1968 by a national group of scientists and conservationists, will present the first of its new conservation awards to George Laycock, field editor of *Audubon* magazine, on January 31, 1970. Mr. Laycock of Cincinnati, Ohio, will receive the award for his article, "The Gator Killers," published in the September-October 1968 issue of *Audubon.* The American Alligator Council cites Mr. Laycock's article for its "vital role in solidifying support of conservation organizations in the fight to preserve the American alligator."

Hartford Grant Received by Osborn Laboratories

Brooklyn, N.Y. – The Osborn Laboratories of Marine Sciences, which have pioneered in studies on drugs from marine animals, have received a grant of $59,520 from The John A. Hartford Foundation, Inc., New York City, to continue studies on pharmacologically active compounds derived from marine organisms.

Researchers at the laboratories have investigated a variety of marine animals for substances having anti-bacterial, anti-veral, heart-stimulating and nerve-blocking activities.

Current research activities are concerned with antibiotic substances obtained from Caribbean deep-sea sponges. The extracts from these sponges are highly effective against a wide variety of disease-producing bacteria.

The Hartford Foundation grant will support research on the purification and chemical identification of the antibiotic substances. Three compounds have been extracted from sponges to date by Osborn Laboratories researchers. One of these chemicals belongs to a class called "indoles," which includes LSD, reserpine, and strychnine, all of which are strong physiologically active compounds.

Researchers involved in the project are Dr. Ross F. Nigrelli, director of the laboratories, Dr. Martin F. Stempien, Jr., and Dr. George D. Ruggieri, S.J.

"There is a constant search for new antibiotics because disease-producing bacteria are in some cases becoming resistant to known antibiotics," said Dr. Nigrelli. "The sea is a fertile ground for this search."

THE bookshelf

ETHOLOGY OF MAMMALS. *By R. F. Ewer. 417 pp. Plenum Press, New York, 1968. $25.00.*

Much new information on the natural behavior of mammals has been published in the last decade, but this information is widely scattered in scientific journals and a good deal of it is in languages other than English. Professor Ewer has gathered together this material and made it accessible to a wide audience for the first time.

The classical ethological theories of Lorenz, Tinbergen, and their intellectual descendents were of course developed mainly in Europe by studies of fish and birds, and tend to stress the importance of species-specific patterns of behavior developed during evolution. American students of mammalian behavior have traditionally concentrated on learned behavior, and have tended to feel that since mammals are so obviously creatures of extremely variable behavior and impressive learning abilities, ethological concepts are largely irrelevant to an understanding of their behavior. The goal of the author is to dispel this misconception by showing, on the contrary, how much of mammalian behavior can be successfully interpreted in ethological terms.

The book is thus intended for a scientific rather than a popular audience, but Ewer has included thorough introductory chapters which should make the theoretical issues clear to all who are interested. Even readers who are not particularly interested in theoretical questions will find the book a goldmine of plain facts on the daily activities of mammals of diverse types. The main topics include expression and communication, food, social organization, territory, scent marking, fighting, threat and appeasement, friendly-behavior, courtship and mating, parent-child relationships, and play. The general reader may be deterred at first by the use of Latin names throughout the text, but will be helped by the glossary of scientific and common names to discover, for example, that *Xerus erythropus* is a giant African rat.

I highly recommend *Ethology of Mammals* to any serious student of animal behavior. It is a pity that its price will prevent many potential readers from obtaining a copy. Katherine Ralls

GREAT GAME ANIMALS OF THE WORLD. *By Russell Barnett Aitken. 192 pp. The Macmillan Company, New York, 1969. $22.50.*

According to promotional material on the flap of the book jacket, the author was voted one of the six greatest living big game hunters. Also, according to the note on the jacket flap, Mr. Aitken was an early patron of the "World Wild Life Fund," and a "conservationist."

The promotional material also asserts that "this book portrays a wide variety of animals in a native habitat in which most readers will never see them" and that many of the animals depicted are "rarely caught by photographers."

According to the author, "The compulsion to hunt is as basic a part of man's nature as the mating urge." He also asserts that, after the thrill of the stalk, "squeezing the trigger is an anti-climax."

There's more. Admittedly, the book contains page after page of superb photographs. Included in these are animals such as the Asiatic cheetah, white rhinoceros, giant sable, takin, and giant panda. The photographs – many of which appear to have been taken in surroundings no more rigorous than some leading zoos – will, according to the jacket flap, appeal to "the lover of animals." Maybe so. But most likely the photo of the puma, dead and strung by the heels, will not. And odds are neither will the photos of the author and others of his "fraternity" proudly standing, gun in hand, with the corpses of dead beasts – dig that blood in full color.

Quite possibly "the lover of animals" might wonder at the author's almost total disregard for the fact that – even though it might be great fun to fill full of lead sundry wild creatures – many of these animals are in appalling short supply. Granted, Mr. Aitken notes that the black rhinoceros is doomed unless given more protection, and that the giant sable is protected, but his overall approach in the book is enough to make this conservationist shudder.

Mr. Aitken is billed in the promotional blurbs as something of an authority on animals. Zoologists among his readers might be interested in his description of the Indian "panther," "a cat virtually identical to the African leopard except that as an average it runs smaller in size."

And try this for writing style: "Multiply it by a thousand and you'll get a sketchy idea of the jitters that rattle a man when his white hunter shoves him up close enough to fox trot with a monster that looks as big as Grant's tomb and is potentially more dangerous than a tornado."

Enough said. E.R.R.

HOMELAND: A Report from the Country. *By Hal Borland. 187 pp. J. B. Lippincott Company, Philadelphia, 1969. $4.50.*

For many years a short "nature essay" on the editorial page of the Sunday *New York Times* has leavened – which is to say, lightened – the whole lump of the week's news. Mr. Borland writes those essays from his home in the Connecticut hills, and four times a year he reports on the seasons and his reflections on men and things of the moment and of eternity in longer essays for a magazine, *The Progressive. Homeland* is a collection of 20 reports for 1964-1968. It is a countryman's report in an old yet ever new tradition – wise, gentle and seasoned – words to correct the ills of an age.

William Bridges

LEWIS AND CLARK: Pioneering Naturalists. *By Paul Russell Cutright. 506 pp., 16 plates, 1 map. University of Illinois Press, Urbana, 1969. $12.50.*

At a time when man has just started to explore some of the other worlds in the universe, it is refreshing to pause and review another earlier period of exploration and some of the adventurers who blazed trails across our home planet. Paul Russell Cutright offers us such an opportunity in *Lewis and Clark: Pioneering Naturalists.* He has a special purpose in this book, however, for while much fact and fiction has already been written about the historic crossing of the North American Continent, in 1804 to 1806, Dr. Cutright's book is the first to be fully devoted to the scientific and technical aspects of the famous journey. Captain Meriwether Lewis, leader and principal naturalist of the expedition, did not live to publish in detail on the many discoveries recorded in his field journals.

Following his return from the west, Lewis was promptly appointed governor of the newly acquired territory of Louisiana. The duties of this demanding post hindered his plans for publication. They were halted altogether by his untimely death in 1809.

Inspired and sponsored by President Thomas Jefferson, this probe into the unknown lands of the west was undertaken to seek a possible navigable water route to the Pacific Ocean by following the Missouri River and its tributaries. The explorers were instructed to report on everything they encountered along the way, both animate and inanimate. They did so in great detail, describing and collecting floral and faunal specimens. Unfortunately, a good deal of the collected material was lost before reaching civilization.

Dr. Cutright has gone to great lengths to set the record of the Lewis and Clark natural history findings straight, taking the reader in their footsteps, across the country, and describing their adventures, hardships, and discoveries. While doing this, he does capture the spirit of this great adventure, but the book is tailored to the naturalists point of view and some general knowledge of biology is necessary to appreciate it fully. The addition of a good map, or maps, delineating the route of the expedition would certainly be a good aid to the reader. The only figure of this type in the volume is one drawing on page 201 marking the crossing of the Bitterroots in September, 1805.

With all due respect to Dr. Cutright's diligence and research, the real impact of this book is in its echo of a day when passenger pigeons filled the skies during migration and the slap of beavers' tails sounded like pistol shots in every river and stream.

Joseph Bell

ABOUT THE authors

Stan Federman is a journalist based in Portland, Oregon. **Wayne King** is curator of herpetology for the New York Zoological Society. **George Leposky** writes on public affairs and the environment. He is a former newsman and now works for a Chicago public relations firm. **Vincent Liguori** is a microbiologist on the staff of the Osborn Laboratories of Marine Sciences. **George D. Ruggieri, S.J.**, is coordinator of research for the Osborn Laboratories. **John Sidney** is a nature writer living in Australia.

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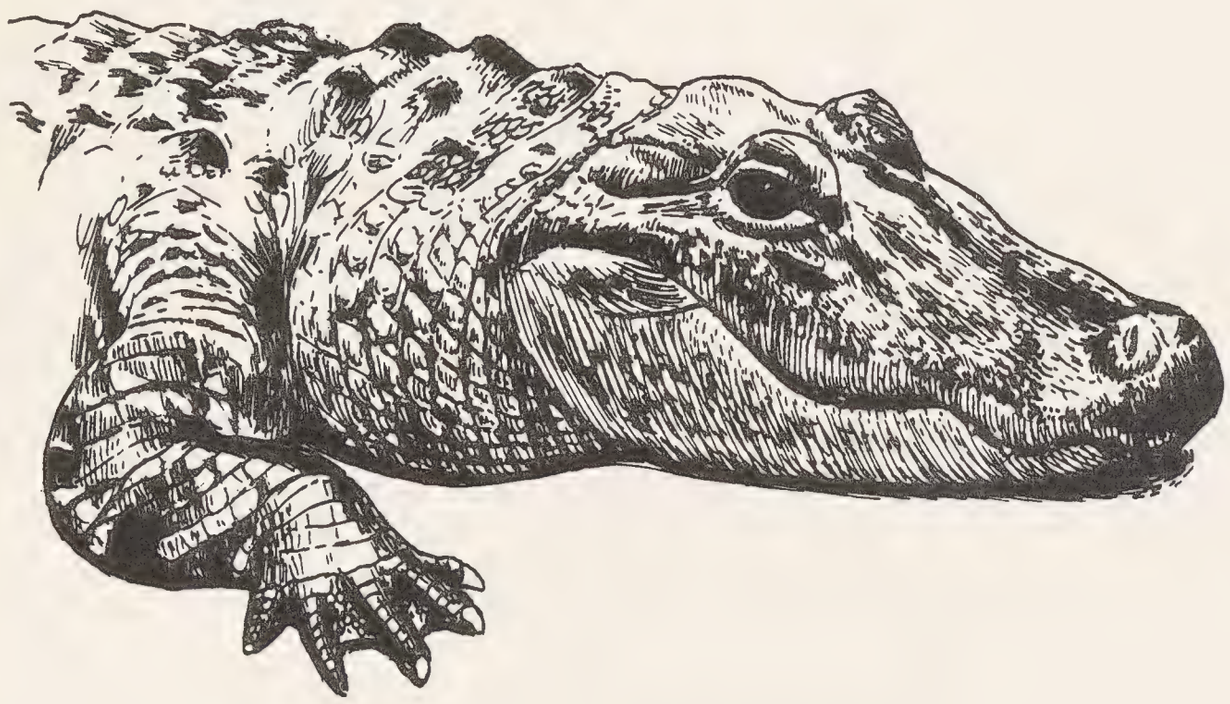
DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo



American Alligator

Alligator mississippiensis (Daudin)

When the early naturalist William Bartram canoed up Florida's St. Johns River in the mid-1770's, he found alligators "in such incredible numbers, and so close together from shore to shore, that it would have been easy to have walked across on their heads, had the animals been harmless." By 1855, however, alligators were being killed regularly to supply a European market with hides used to make shoes, boots, and saddlebags. From 1800 to 1891, an estimated 2,500,000 alligators were killed in Florida. From 1800 to 1933, approximately 3,500,000 were killed in Louisiana. In 1929 alone, 190,000 skins were sold in Florida, and because of the slaughter, the wild gator populations in that state declined until in 1943 only 6,800 hides were sold. Similar declines in numbers of wild alligators were experienced throughout their range because of increased hunting pressure.

As the gator became scarce, the market value of alligator hide increased. In 1929, hides were being sold for 70 cents a foot. By 1943, the price had risen to $3.00 a foot. Now gator hunters are paid $7.00 to $8.00 a foot.

As the alligators began to vanish from North Carolina south to Florida and west to Texas and Arkansas, each state passed protective legislation. Today, the American alligator is protected in every state in which it occurs naturally, and every new hide sold was taken illegally. However, the market price of hides more than compensates a poacher for fines he might incur, and the ease with which poached hides can be slipped across state lines and sold in northern states mocks the efforts of the southern states. Poaching is encouraged by the willingness of tanners and manufacturers to buy alligator hides.

The American Alligator Council and the Association of Southeastern Fish and Game Commissioners are attempting to coordinate alligator conservation efforts between individual states, the federal government, and research biologists. And the council is endeavoring to generate more public interest in alligator conservation.

The federal endangered species bill should control interstate traffic in alligator hides and products and thereby eliminate the illegal market and the poachers.

Studies by the Florida Game and Fresh Water Fish Commission show that the numbers of alligators in south Florida declined 30 percent in the 14 years between 1954 and 1968. With adequate protection, the American alligator might reverse this plunge toward extinction. Continual drainage of wetlands will cause a restriction of its former range, but the alligator will remain an observable part of the fauna of the southeastern United States if hide-hunting can be stopped.

WAYNE KING

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animal kingdom

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ABOUT THE COVER

Front: Siberian ibex *(Capra ibex sibirica).* Native to the great mountain ranges of Asia, from Afghanistan east to central Siberia, this wild goat is a member of the Family Bovidae. A large family, which includes the antelopes, wild cattle, goats, and sheep, the Bovidae has representatives in Africa, Asia, Europe, and North America. For a report on another member of the family, the Malaysian gaur or seladang, see page 2.

Back: Indian pitta *(Pitta brachyura brachyura)* is a solitary bird which lives in forest or brushland; mainly terrestial, it roosts in trees and perches to sing.

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SELA

by Les Weigum

DANC

Quietly and now very slowly we followed the fresh track. Sammat, my tracker, was in the lead and visibly nervous. Often stopping and glancing back, he obviously thought we were close. The surrounding dead brush was a seven-foot-high barrier that had but one opening. As we wriggled through, the jungle suddenly exploded. The thicket crackled and broke as the animals stampeded away. Within five seconds all was quiet and I stood alone.

"Psst"—Looking down at me and grinning sheepishly, my tracker was safely enscounced in a rubber tree. Following his lead, I nervously climbed a tree. As I reached the fork and could see over the brush, I caught a glimpse of a short black tail disappearing in the thicket. This was my introduction to the Malaysian gaur *(Bos gaurus hubbacki)*.

In 1967 the Malaysian Game Department asked me to study the biology of the gaur. Never abundant, these noble wild cattle have already disappeared from several of the Malaysian states. With projected jungle clearing projects and new dams, some gaur herds presently inhabitating these areas are threatened. Knowledge of the animals' requirements is therefore needed if the remaining herds are to be preserved. From July 1967 to July 1968, my work was supported by the Peace Corps. In September 1968, I was given a grant from the New York Zoological Society and the Canadian Wildlife Service to continue the research for another year.

For such a study I chose an area in the Malaysian Taman Negara (National Park). The park is in central west Malaysia and takes in 1,677 square miles of virgin jungle, mountains, and rivers. It is well isolated, and travel is by boat or foot. There were several known herds in the park and I eventually chose a herd which was easily accessible from park headquarters (Kuala Tahan).

The guar is a near-relative of domestic cattle. It is found in India, Nepal, Burma, Indo-China, and the Malaysian peninsula. The Indian gaur, Burmese gaur, and Malaysian gaur have been designated separate subspecies. The Malaysian gaur, which is also called seladang, is usually found in herds of about 11 animals, though solitary bulls are not unusual. Adults are dark brown and often appear black. They have a conspicuous raised dorsal ridge which runs from the neck to the middle of the back, characteristic white stockings on the legs, and two dewlaps—pendulous folds of skin. The larger of the two dewlaps hangs beneath the neck and a smaller dewlap can sometimes be seen under the chin of old animals. Seladang are deep-bodied with short legs. Their hooves are small and slender and I often wonder how they can support such a large bulk.

The bull is larger than the cow, and one male has been recorded as six feet, three inches to the top of his shoulder, though this must be a record. One young black bull which was immobilized with the drug M-99 measured four feet, ten inches to the top of his dorsal ridge. Besides size, bulls can readily be distinguished from cows by their thicker and wider horns. Neither, however, have very large horns, perhaps because this would prove disadvantageous in an environment of thick undergrowth.

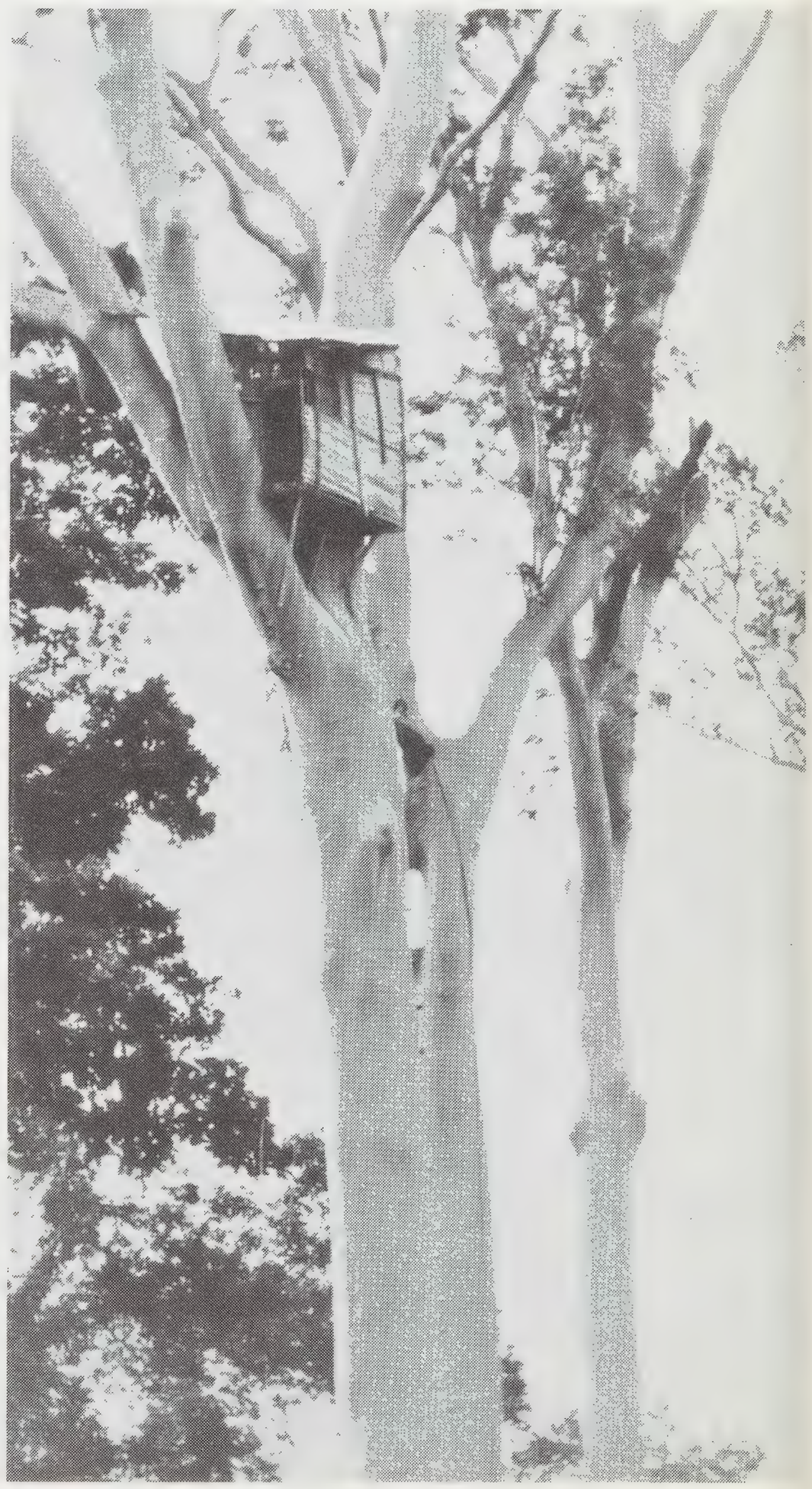
It is difficult to remain undetected when near the extremely wary gaur herd. With an incredible sense of smell, the animals need depend little upon sight and sound. I have climbed a tree with a group of gaur standing only 60 feet away, and though they watched me uneasily they remained until the wind shifted. Such behavior is often mistaken for

The seladang herd grazes in the 21-acre study field (above). An observation blind was built 106 feet from the ground in a large tree overlooking the area (below).

aggressiveness and the local people have a strong fear of the gaur.

Stumbling upon a herd can be quite an experience. Usually the seladang are aware of one's approach and the typical reaction is a loud terrifying snort followed by a headlong rush to escape. Trampling bushes and small trees, the seladang run for a short distance, stop, and then quietly walk away. If the intruder is not intimidated, then the second type of encounter will really test his mettle. As a typical example, I was one day stalking the herd and stopped near an abandoned pig wallow. The seladang were perhaps 200 yards away, hidden by the jungle. As I sat gazing at a dragonfly laying her eggs in the stale pool, I suddenly had an uneasy feeling and glancing up saw the large form of an old female gaur intently looking at me. I sat still trying to ease my camera from its case. Only 80 feet away, she tossed and shook her head. Walking slowly forward, while blowing and snorting, she tried unsuccessfully to wind me. Finally she stopped 35 feet away. The flies were buzzing around her dark eyes and drool dribbled from her chin. She got the scent and with a sudden snort wheeled and crashed off. Such behavior is not unusual and is fuel for many "miraculous" escape stories.

The seladang cannot be called a jungle animal. They travel and will often rest in deep jungle, but their food is in clearings and disturbed areas. This habitat is either man-made or riverine (due to constant flooding). In the park, of five known



herds, all but one exist in areas previously cleared by man. Outside the park this association has taken its toll as wild "beef" is a big temptation to gun owners.

The Kuala Tahan herd, which I chose for my study, occasionally visited a small clearing near the park headquarters compound. Reasoning that an even larger area would be more attractive, the staff doubled and then tripled the field to 21 acres. An observation blind was made in the crotch of a large tree, 106 feet above ground. Near the center of the field, I buried a bag of rock salt. The frequency of herd visits remained the same, but the duration was extended from a seven-day average to 13 days.

During the two-year study, the size of the herd has fluctuated between 11 and 19. This is due to recruitment and movement from the herd. The basic herd which has not varied during this time consists of eight adults. Two bulls, three young, and three old females, plus calves and yearlings, make up the herd. Two other bulls and at least six additional adult females (young adult females are extremely difficult to individualize) have at one time or another been associated with this herd.

The leader is a large female. She is similar in many ways to the master bull. Not only is she the largest female, but her horns are less incurved than other old females. She also has a distinctive yellow tip on her tail. Her picture was taken in 1960 when she was approximately three-to-five years old. Perhaps 13 years old now, she looks strong and healthy. Daily feeding and range movements are initiated and led by her. She remains at the edge of a clearing until satisfied it is safe, then either takes the herd back into the brush or feeds in the open. She is very nervous and always alert. Man and tiger are the herd's only predators, and if she smells man they invariably retreat. Tigers are, however, a different matter. I was once witness to such a confrontation.

The master bull (also shown on page 2) stands in the center of the herd in the study field. At the time the photograph below was taken, the bull had a swollen right front knee.

Grazing in the study field at 6:00 P.M., the seladang paid no attention to the distant rumbling of a tiger. In fact only a yearling bothered to raise his head. The tiger was perhaps a mile up-river and was no cause for alarm. Every five minutes though, the call was heard closer. Suddenly the quiet was broken as the tiger loudly announced himself at the field. The herd was grazing about 400 feet from him. No panic or even retreat was seen as the whole herd unhesitatingly hurried toward him. Snuffling and blowing, the old cows led the "charge." In the rear, the master bull remained at the side of a female and her young calf. They were all near the tiger's position, and as the bull guarded the five calves and cow, nine others left the short grass searching for the big cat. Blowing loudly with noses near the ground, they resembled hunting dogs following a scent. Closing in on their adversary, two young females leaped back as the tiger snarled. Bellowing and snorting, the big bull lowered his horns and rushed in. This was too much for the tiger and he fled. Later he was heard farther down-river. The seladang remained in the brush snorting and blowing until dark. All 16 were placidly grazing the next evening. Tigers most certainly take young calves, but during my study I cannot confirm any losses to tigers.

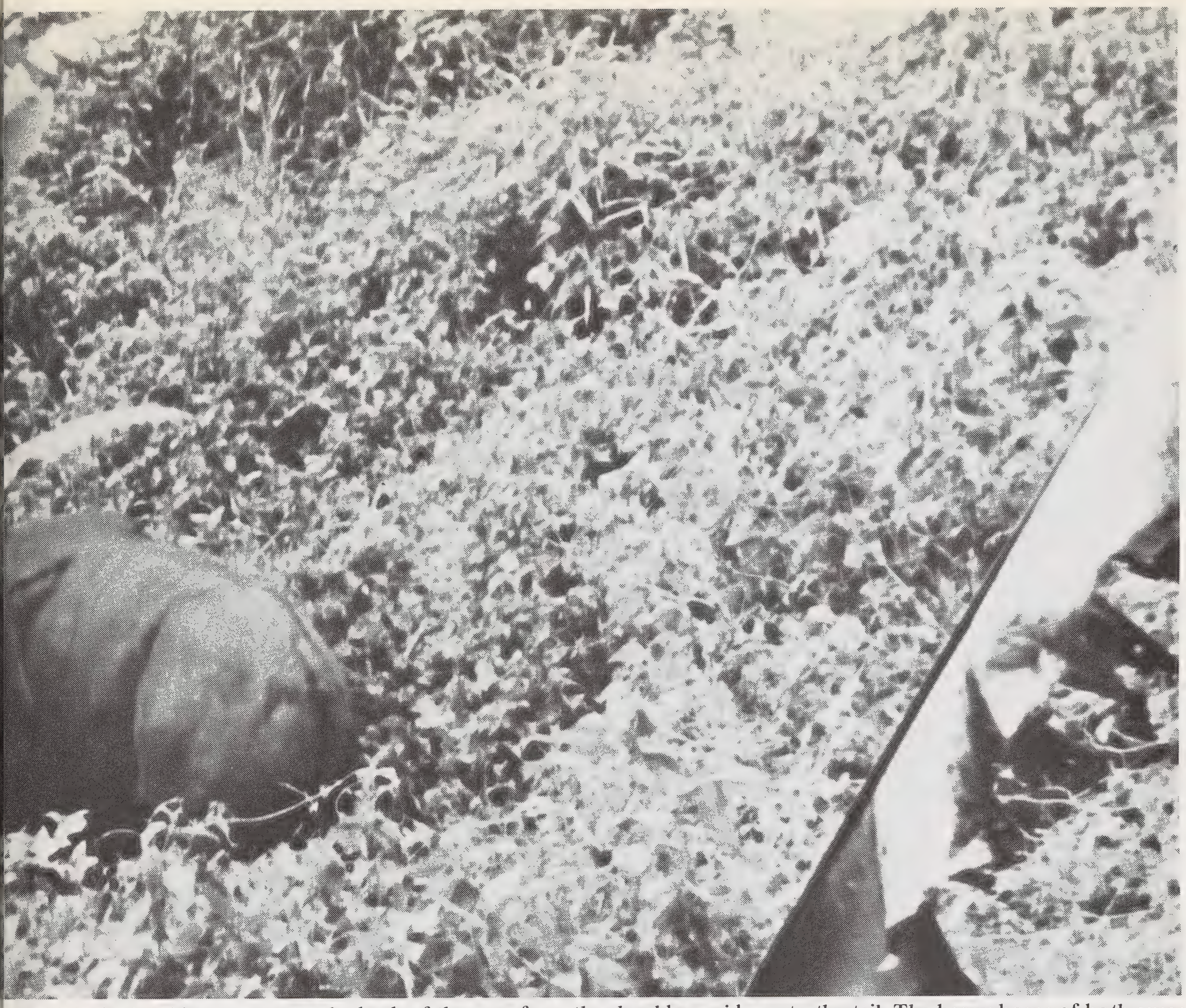
Dominance within the herd seems to be based upon size. The master bull is the largest animal and all are subordinate to him. This dominance can be seen when they gather at the salt lick. The big bull will sometimes let several old females share the pit, but all others are driven away. In general, old cows, young cows, two-year olds, yearlings, and calves follow in descending order. Black bulls moving into the herd fit in at various places. One large bull that joined the herd was subordinate to only the master bull, whereas other smaller bulls sometimes ranked even below young cows.

This order is further demonstrated by head wrestling. Though I have witnessed this sparring on only three occasions, it followed the dominance pattern seen at the salt lick. Head to head the gaur twist and turn as the larger pushes his opponent. I have seen all size groups participate in this "sport." Calves and yearlings particularly seem to enjoy it as they run and jump playfully. Serious bouts between bulls is probably uncommon. I have seen rump gashes on an adult bull and an immature brown bull. In 1954, however, there was a fatal encounter in this herd. The chief game ranger related that upon investigating a noisy thrashing in a nearby clearing, he saw two large bulls engaged in violent head wrestling. The herd

grazed as the two sparred. One bull finally withdrew to a hillock. The dominant bull turned, presenting his side to his subordinate. The subordinate charged and hit his rival in the side. The dominant bull fell and was impaled by a sharp tree stump. With a pierced hip he struggled up and limped off. Two weeks later he was found dead six miles from the skirmish.

Perhaps because the wet and dry seasons alternate irregularly from year to year, there is no particular breeding season. Six calves were born during my study; two in February-March, one in early June, and three in September-October. Generally it is rainy during the last three months of the year and extremely dry from January to April.

Calves are born distinctively rufous in color with a dark dorsal stripe. There is no sign of the dorsal ridge or white stockings. This coloration lasts only a month as the calf begins to darken. At two-and-one-half months, there is a blackish patch above the nose, dark coloration just above cream-



A high, fleshy ridge surmounts the back of the gaur from the shoulders midway to the tail. The heavy horns of both sexes turn upward, then in, with a haired, bony ridge between them. Shown here is a young black bull.

colored stockings, and a black ventral stripe under the neck which is larger where the dewlap will develop. Some gaur gradually darken until at one year they are nearly adult-black. Others remain lighter and one yearling bull in the study herd still retains his juvenile color. Calves suckle for three months and most probably up to five or six months. At one year males and females can already be distinguished by horn curvature.

Seladang are nocturnal and diurnal, but mainly crepuscular. They graze in open fields from one to two hours before dawn. At dawn they move into brush and either may continue browsing or may rest. Visibility seems to be more important than temperature in seeking shelter. By 1:00 P.M. most members of the herd are lying ruminating and remain inactive until about an hour before sunset. Browsing again in thick brush, they usually venture into clearings at sunset. On the few occasions that I have been able to observe them through the night, the adults have actively grazed until near midnight. Young and older calves lie down most of the night, while the adults rested between midnight and near dawn. Rain affects this routine very little. During the day they will stand huddled together either in the brush or jungle. At night they simply graze.

The seladang have a varied diet. The grasses and sedges constitute a major part of this diet. Of 20 identified species, *Paspalum conjugatum,* because of its tenacity and abundance, is the most important. A great number of forbs and shrubs provide the seladang with browse. Many non-woody vines, particularly the planter's scourge, *Mikania cordata,* are sought. Unfortunately seladang actively seek such cultivated crops as rice, banana, pineapple, tapioca, and—worst of all—rubber leaves. Only the leaves of rubber saplings and new shoots are eaten, and though the tree usually survives, rubber tapping may be set back years. The jungle provides little food for the gaur. Some saplings and several palm species are browsed. The fruit pods of the

A seladang with its prehensile tongue feeds on a rubber sapling. Only the leaves and new shoots are eaten, but such browsing can set the plant back years in its development.

large kerayong tree *(Parkia javanica)* are taken in season.

The study herd ranges over an area of nearly five-and-one-half square miles. Usually they remain within 240 acres of government land. Seven years ago the government cleared and planted this land with young rubber trees, which are now being tapped by the villagers. The seladang have enjoyed the luxurient growth of grasses and shrubs on this land. Farther down-river and still outside the park are many abandoned rice fields. These fields are left idle from between two and six years, and thus there is a renewable food source for the herd. The herd moves between these areas just before dawn, traveling on a maze of well-defined trails, both in secondary growth and jungle. They cross the two major rivers in only three places shallow enough for the herd to cross without swimming. The herd moves in single file. The lead cow is followed by the master bull, cows and young calves, yearlings and older calves, and lastly an adult female. They habitually rest in particular places—sometimes in brush, sometimes in jungle, and sometimes in grass, depending upon the time and area. The coarse lalang grass *(Imperata cylindrica)* is the most preferred night bedding.

Two salt licks are within their range—one natural and the other artificial. On only two occasions have I known the seladang to visit the natural lick. This lick, rich in calcium and sodium, is along a small stream and is mainly utilized by sambar deer and tapir. The artificial lick has been visited by the herd six times and sporadically by individuals. Staying an average of 13 days, the gaur eat the salt-impregnated earth during the first four to five days. Whether or not they take the salt as a needed supplement or for removal of internal parasites (as suggested by some authors), subsequent dung piles are mainly mud.

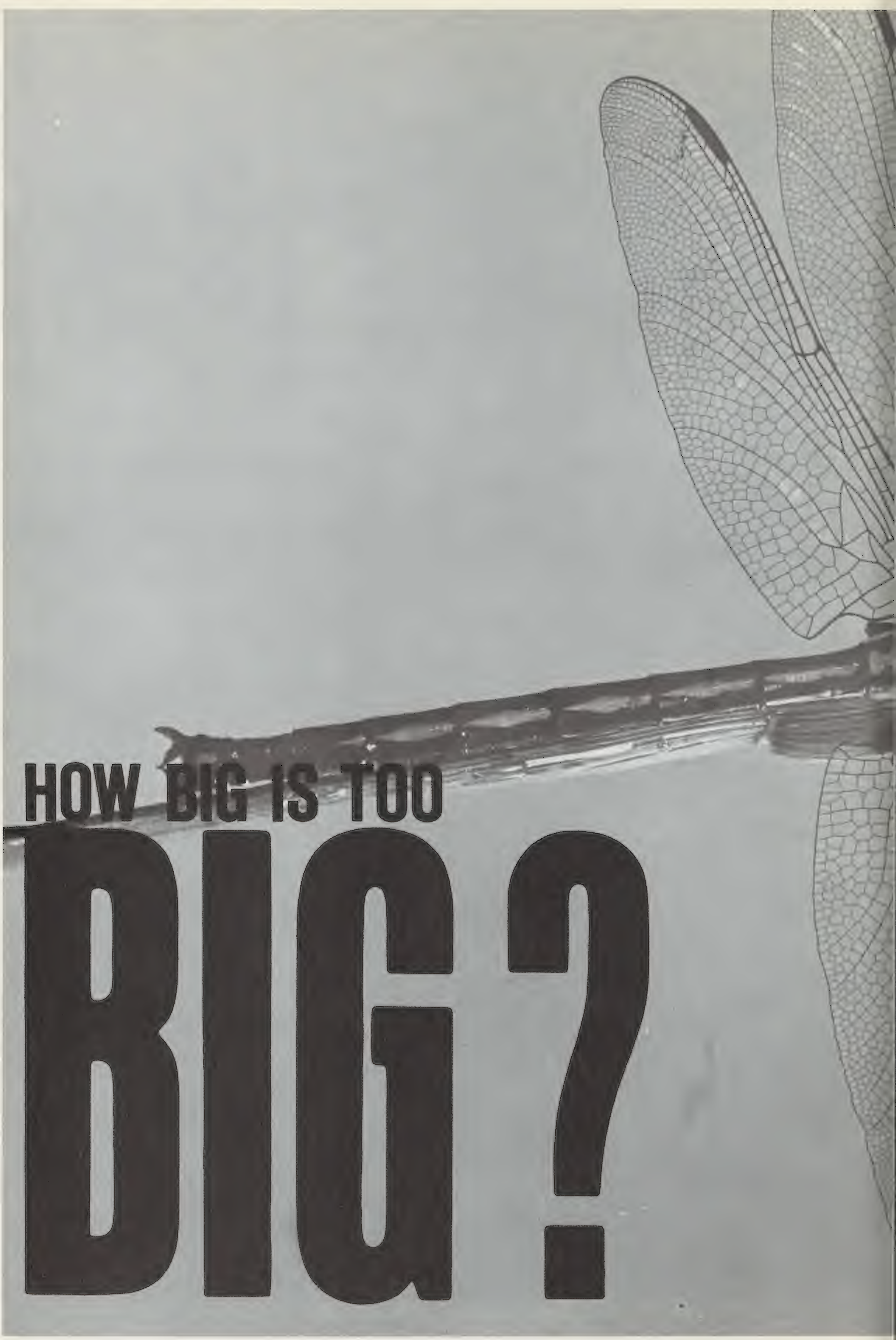
Although seladang do not wallow as do pigs and sambar deer, they have a curious habit in relation to the known wallows. When in an area of a wallow, provided it is wet, the gaur congregate in the soft mud, sometimes sinking to their knees in

the ooze. Never have I known any to roll or lie in the mud. They seek these wallows, especially after a rain, in the afternoon.

When disturbed, seladang blow and snort. If they are about to face danger, a loud challenging bellow is issued. This is best described as a "roar" and can originate from either bull or cow. Dusk finds them in this challenging mood, and many times I have retreated as they refuse to leave. More common and rather like a musical grunt is the call made at sundown. This again is made by either sex and seems to be used in a variety of situations. Lasting for as long as three-and-one-half seconds, it begins high and always ends lower (musically). I have heard scattered animals calling and answering. Once I counted 31 such calls within a half hour. Least often heard is the lowing and mooing associated with domestic cattle. In general, gaur are not vocal.

The National Park has a seladang population of approximately 70 animals. This is an estimate from known groups in and around the park. Perhaps the actual population is closer to 100. With the seladang's dependence on primary and secondary growth, the game department has begun making suitable habitat by cutting, clearing, and planting. The future of the Malaysian gaur must eventually be decided in the parks and in particular the National Park. It is most likely that here will be the last sanctuary of the seladang, but the park is large enough so that with judicious planning a small population can be maintained.

Dominance within the herd seems to be based upon size. A two-year old female ranks rather low within the herd, coming after the master bull, old cows, and young cows but before the yearlings and calves.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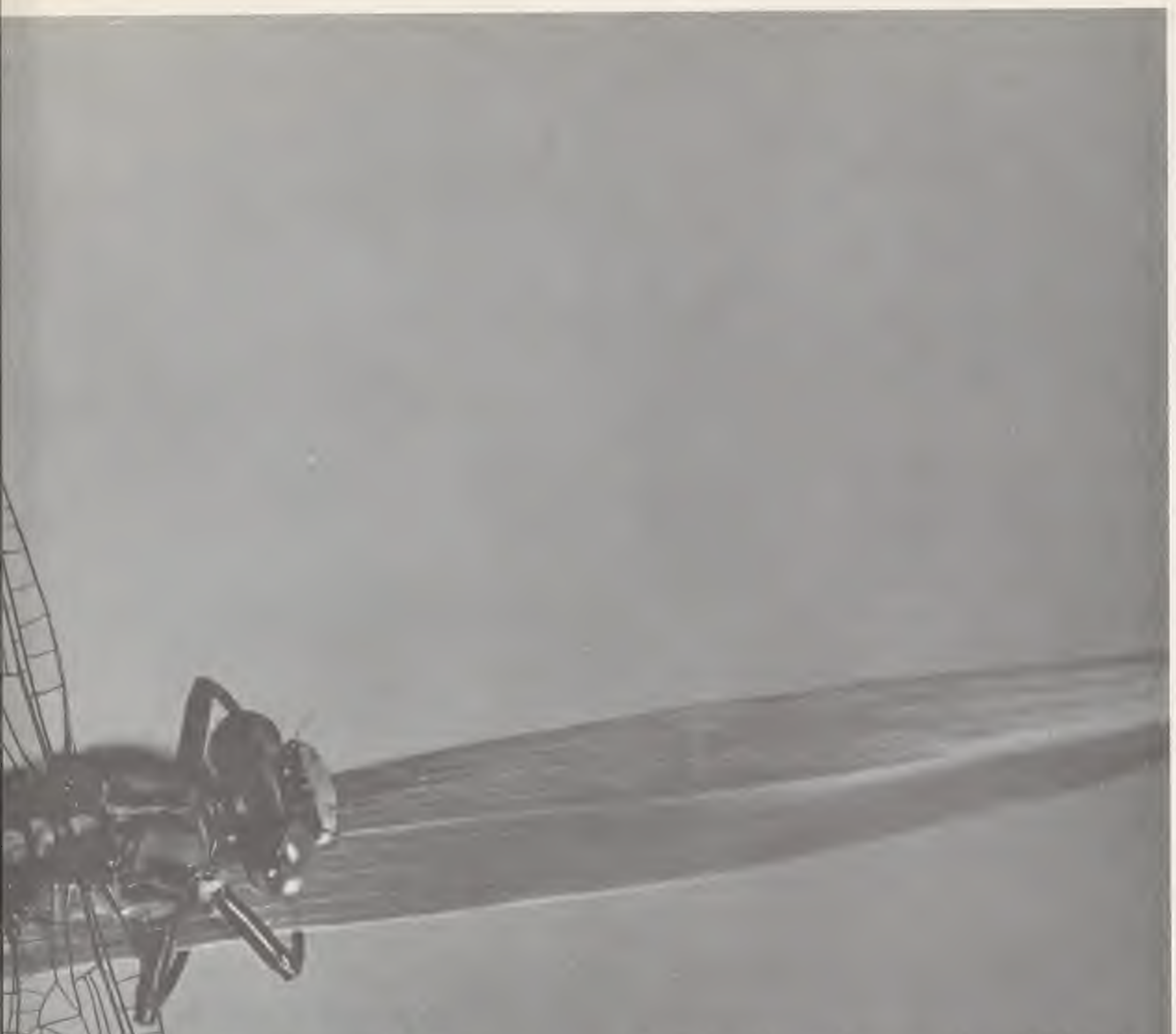


The Limitations of Insect Size
by Edward Edelson

Of all the monsters that come stalking across movie screens, some of the most frightening are giant insects—ants or beetles, magnified up to 50 feet or more, which picturesquely smash up cities until the scientist-hero wipes them out. And from what we know of insects, the prospect does seem genuinely frightening. For their size, insects can perform amazing feats. An ant can lift 50 times its own weight; a flea can jump nearly eight inches high. Therefore, scaling an insect up to human size apparently would create a being able to lift four tons or high-jump 450 foot.

But fortunately, man-sized insects can exist only in the imagination of writers of monster movie scripts. If a 150-pound insect were somehow created, it would have none of the immense powers attributed to it. In fact, a giant insect would collapse of its own weight—if it didn't die of asphyxiation first.

Nature has designed insects to be small. Indeed, smallness is a major reason why insects are the most numerous beings on our planet. Insects have been around long enough—more than 300 million years—for evolutionary forces to have established an optimum size. The fact that many fossil insects are bigger than their present-day relatives indicates the survival value of smallness.

The largest known insect was a prehistoric dragonfly that had a wingspan of 29 inches. Today, the largest insects are considerably smaller. The Australian stick insect *(Phalophus titan)* is 10 inches long. The Atlas moth of India has a 12-inch wingspan, while the great owlet moth of South America *(Thysania zenobia)* has a wingspan of 12 inches. For bulk and power, the leadership goes to the African Goliath beetle *(Goliathus regius)*, which can be five inches long. There are stories of Goliath beetles bending house keys that had been placed between the insect's neck and thorax, and this beetle must be handled with care for fear of finger injuries. Another beetle, the Hercules

(Dynastes hercules), is longer than the Goliath, reaching a length of six inches, but part of that consists of two horny projections, from the thorax and the head.

At the other extreme are such microscopic insects as the "fairy fly," actually a wasp, which is small enough to deposit its eggs inside dragonfly eggs and which is no more than 1/100 of an inch long at maturity. Some British beetles of the family Trichopterygidae are about the same size—small enough to crawl through the eye of a needle without much difficulty.

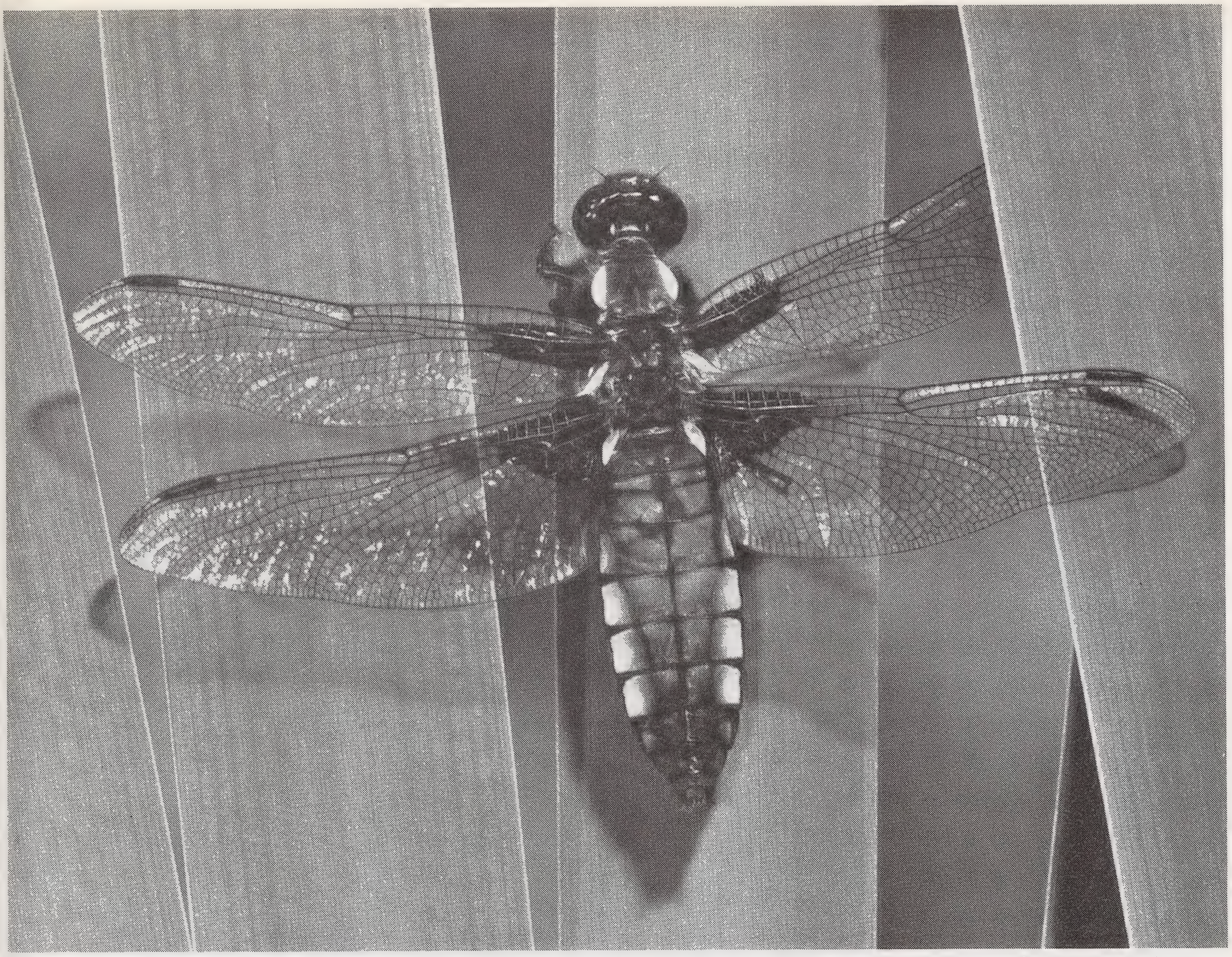
This is an enormous range. While an elephant is only 100 times taller than a mouse, an Atlas moth is more than 1,000 times larger than a fairy fly. Most insects, of course, are in the middle of this range. The overwhelming majority of insects are under an inch in length, and most are less than half-an-inch long.

There are three general reasons why insects are so small. One is the survival value of smallness. As Sir Vincent B. Wigglesworth of the University of Cambridge, one of the world's leading entomologists, points out, "Small insects require less food to reach maturity, just as it was the small-sized men who survived the conditions of semi-starvation in some camps for prisoners of war. Small insects can make use of small retreats to escape their enemies. Indeed their small size opens to them a whole world that is not accessible to larger animals. To mine between the walls of a living leaf, to complete their growth within a single small seed, or to develop within the egg of another insect, is possible only for a very small animal."

In addition to this positive reason for smallness, there are two negative reasons why insects are limited in size. The first involves their method of getting oxygen to the body's cells. Vertebrates use a circulatory system driven by a heart, in which oxygen is carried by pumped fluid. Insects, by contrast, have a heart with a relatively open circulatory system and a network of tracheae, almost microscopically small tubes that carry air to every part of their bodies. This system relies on diffusion of gas to renew the oxygen supply, for the insect's "blood" sloshes about comparatively haphazardly.

However, diffusion is effective only for a short distance. Most insects help diffusion by methods that increase the movement of air. The grasshopper, for example, has an abdomen that pulsates slowly, driving air through the tracheae; many other insects have air sacs—expanded tracheae—

The Hercules beetle is named after the hero of Greek and Roman mythology who possessed extraordinary strength. The beetle uses the horny projections in ritual combat, literally throwing over its opponent.



Most insects today are less than a quarter of an inch in length, but the fossil of a prehistoric dragonfly shows a wingspan of 29 inches. The dragonfly is one of the few surviving insects that cannot fold its wings back over its body.

that act as bellows to help move the air. But these methods are effective only up to a point, and the basic limitation is the rate of diffusion of air.

The final factor that influences the size of insects is their use of an external skeleton. The insect's shell, or exoskeleton, is remarkably effective on a small scale. It becomes more cumbersome as body size increases. As Sir D'Arcy Wentworth Thompson said in his classic study, *On Growth and Form:*

"The mechanical structure of insect or crustacean is highly efficient up to a certain size, but even crab and lobster never exceed certain moderate dimensions, perfect within these narrow bounds as their construction seems to be. Their body lies within a hollow shell, the stresses within which increase much faster than the mere scale of size; every hollow structure, every dome or cylinder, grows weaker as it grows larger . . . A hollow shell is admirable for small animals, but nature does not and cannot make use of it for the large."

What makes the exoskeleton even more critical in limiting size is the potential crisis at the moment when a growing insect molts a shell which is becoming too small. It takes several minutes for the soft outer layer of cells to harden and form the new exoskeleton. Above a certain size, the pull of gravity would distort the shell before it hardened, so that the insect would literally collapse because of its own weight.

Once the limitation of smallness is established, a whole spectrum of interrelated problems and possibilities is created. A perfect example is the relationship of insects to water. For most insects, water can be a menace as deadly as poison. J.B.S. Haldane outlined the problem in his essay, "On Being the Right Size":

"A man coming out of a bath carries with him a film of water of about one-fiftieth of an inch in thickness. This weighs roughly a pound. A wet mouse has to carry about its own weight of water. A wet fly has to lift many times its own weight and, as everyone knows, a fly once wetted by water or any other liquid is in a very serious position indeed. An insect going for a drink is in as great danger as a man leaning out over a precipice in search of food."

Nevertheless, some insects manage to live very

comfortable lives on the surface of lakes and streams and even on the ocean. They take advantage of a phenomenon called "surface tension." Molecules on the surface of a liquid are attracted more by each other than by molecules of the surrounding air. It is this attraction that makes a drop of water contract into a hemisphere, which has the smallest area for its volume. In effect, surface tension is an invisible elastic film on the surface of the water.

People use surface tension for a parlor trick; with proper care, it is possible to float a needle in a glass of water, since the surface film is strong enough to support it. Some insects have adapted to take advantage of this phenomenon.

Among the insects adapted to a life spent on the surface of ponds are the water strider (above), with its slender legs and light body covered with tiny hairs, and the whirligig beetle (opposite), often found in large groups swirling around in all directions.

The water strider, for example, can not only glide across the surface of a pond, it can also jump and land safely on water. The water strider has a long narrow body, with extremely long middle and hind legs (its shorter forelegs are used for grasping prey). The middle and hind legs have tufts of hair at the ends; air trapped in the hair keeps the strider safely out of the water.

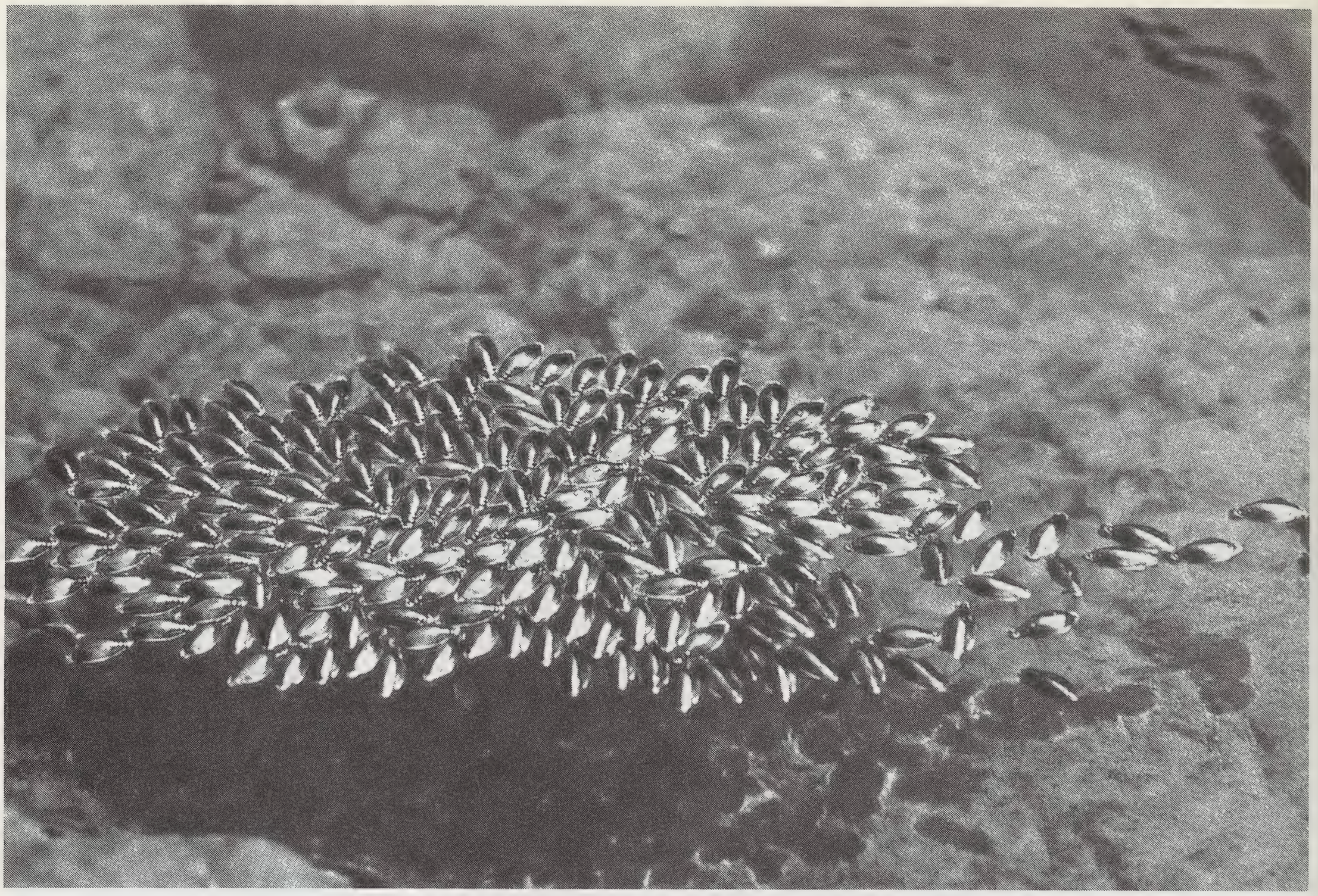
The whirligig beetle, another surface dweller, has an equally ingenious adaption. The upper part of its body repels water and so remains dry, while the lower half and the legs are kept constantly wet. The whirligig beetle can dive beneath the surface and emerge safely; its eyes are divided into underwater and above-water components, so that it has separate views of both.

Other insects produce a waxy secretion on their feet that helps them walk on water. The adaption can be remarkably effective. Some water striders live their lives in the ocean, hundreds of miles from shore, laying their eggs on floating seaweed.

The final relationship between insect size and water concerns retention of body water. In this case, small size is a disadvantage, since smaller animals have larger surface area in relation to their volume. Since water is lost through the body's surface, an insect could desiccate without a means of reducing evaporation.

Water loss in insects is prevented by a thin amber-colored membrane, less than a thousandth-of-a-millimeter thick, which is called the epicuticle. The fragility of this protection can be demonstrated if a caterpillar walks over a piece of blotting paper that has been lightly dusted with an abrasive. The abrasive wears away the epicuticle and the caterpillar will shrivel and die within hours.

Just as it effects the insect's outer surface, smallness also affects the way the insect



The whirligig beetle feeds on other insects that fall in the water. Its eyes are divided to give separate views of both spheres in which its body dwells, the dry air above and the water below.

sees the world. D'Arcy W. Thompson pointed out that the size of rods and cones—the cells that receive visual images in the eye—are limited to a narrow range by the size of light waves. Thus, he said, the difference between a whale's eye and a squirrel's eye is far smaller than the overall size difference between the two species.

"But," Thompson went on, "the insect's eye tells another story. If a fly had an eye like ours, the pupil would be so small that diffraction would render a clear image impossible. The only alternative is to unite a number of small and optically isolated simple eyes into a compound eye, and in the insect nature adopts this alternative possibility."

Most insects have a very large number of units in their compound eyes. The drone bee has about 13,000, the water-beetle about 9,000, and the housefly about 4,000. Seen under a microscope, the compound eye of an insect looks like subminiature honeycombs. Each facet is, in effect, a tiny visual system, with a lens, retinal cells, and a light-transmitting mechanism. All the images are put together in the insect's brain to give it a view of the world. Insects are believed to have only a hundreth or less (depending on the number of facets in the eye) of man's visual acuity. However, the compound eye is very effective in detecting movement, since any object in position will register on a number of facets in sequence, and this is of prime importance in a being whose major purpose in life is to avoid capture by a predator.

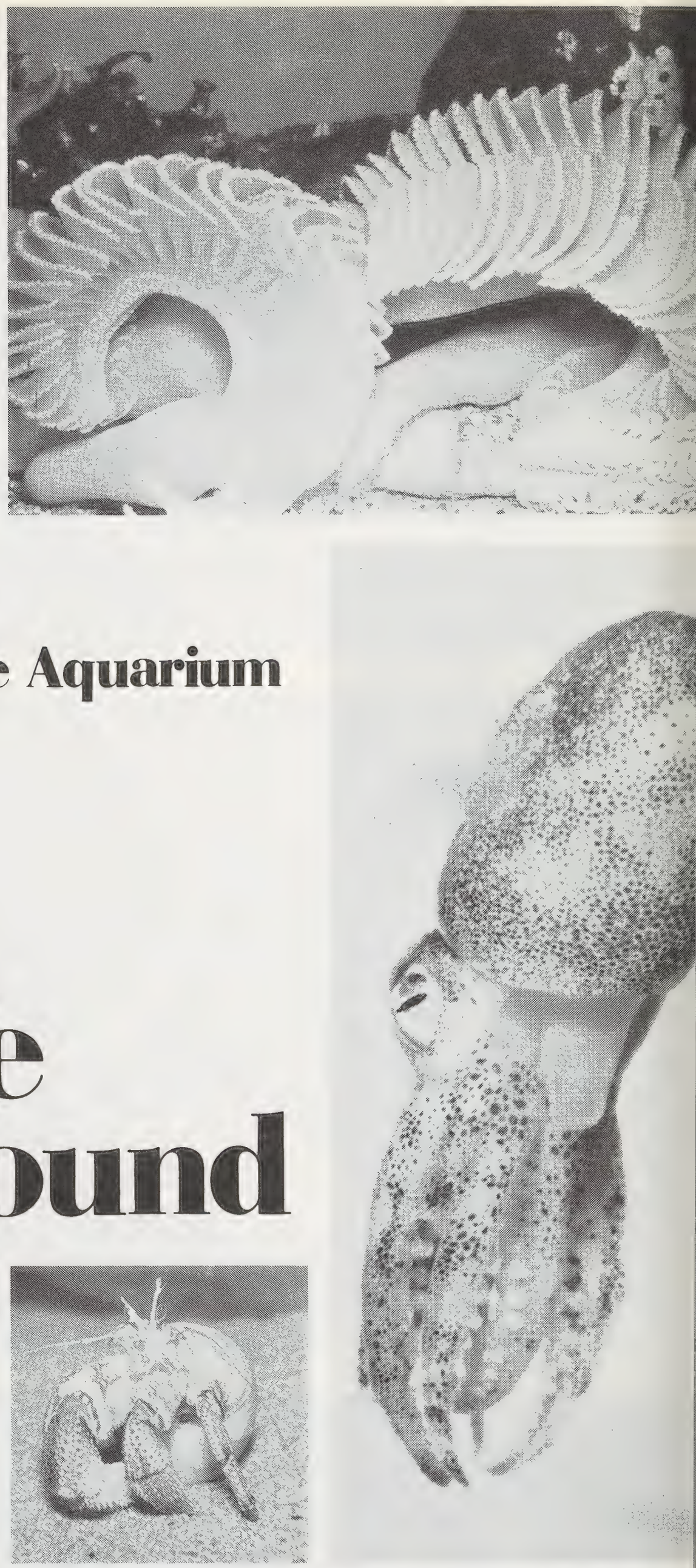
The list could go on and on, since every aspect of an insect's existence is conditioned by its smallness. So it is with the insect's feats of strength. These are impressive only proportionally and are made possible by smallness. The absolute power of a muscle is measured by the amount of weight lifted for a given cross-section of the muscle; length is not considered. The muscles of vertebrates usually are long and spindle-shaped, attached at the ends only. An insect's tend to be short, with each muscle fiber being attached at both ends. Every fiber contracts almost at once, exerting tremendous force. While the absolute power of insect muscles is no greater than that of vertebrate muscles, they do work more efficiently. But if insects were somehow scaled up in size, they would lose their edge in efficiency. A beetle as big as a man would do well if it could simply drag itself around.

But to think of a man-sized insect is as absurd as to think of an insect-sized man. Within its own sphere of size, the insect has made evolutionary adaptions at least as successful as those made by man.

The Ballet of The Swans

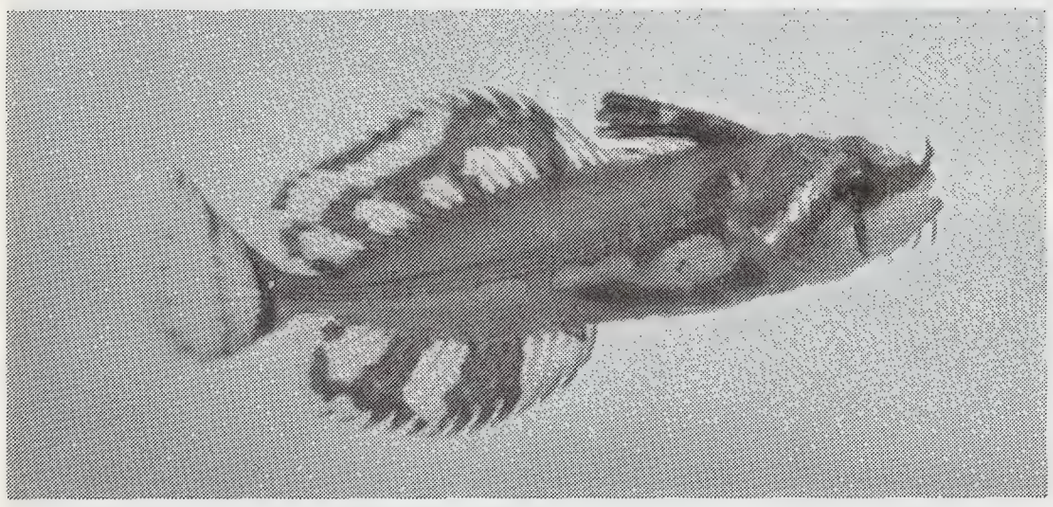
Photographs by Gerhard Budich

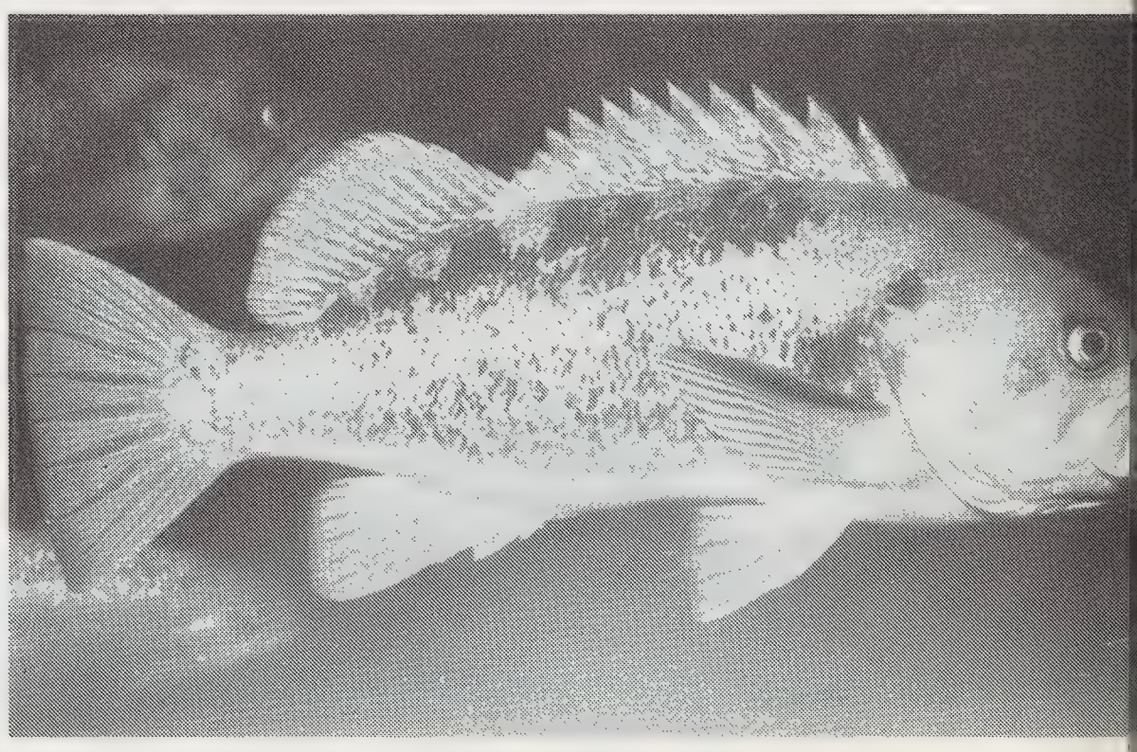
The graceful aquatic ballet pictured here consists of stages in the mating ritual of the mute swan. The mating process of these birds is composed of a pattern of regular, consecutive stages of behavior. When mute swans mate, they always follow this pattern – for them, there is no other way. Time after time, the ritual is repeated by paired swans. Therefore this behavior typical of its species identifies the mute swan just as positively as does its appearance, habitat, or anatomy. The photographs were taken in Germany.



A Visit to the Point Defiance Aquarium

Marine Life of Puget Sound





Above: silver spotted sculpin
Center: hermit crab
Top right: sea pens
Middle right: bottom squid
Lower right: rockfish

by U. Erich Friese

After a short, ten-minute drive from downtown Tacoma, Washington, heading northwest along Commencement Bay and leaving the bustling waterfront activities of this large seaport behind me, I approached the Point Defiance Park. Driving through the park my car moved along narrow, but well-paved roads, which meander slowly uphill, past gaily colored flower beds, ponds with waterfowl, and an attractive Japanese garden. Passing under some stately evergreen trees, my car eventually reached the crest of the hill. I saw a curiously circular building to the left of the road, slightly below me, nestling snugly against the gently sloping hillside – the Point Defiance Aquarium, famed for its novel approach to the display of Puget Sound marine life. This was to be my first visit to this unique institution.

I parked behind the building, and as I walked down a short path toward the aquarium's main entrance, I saw a crowd of people milling around in front of the aquarium. As I came closer the reason for their presence became obvious; a number of harbor seals, *Phoca vitulina,* and some northern fur seals, *Callorhinus ursinus,* were putting on a show in the pools outside the aquarium's main entrance.

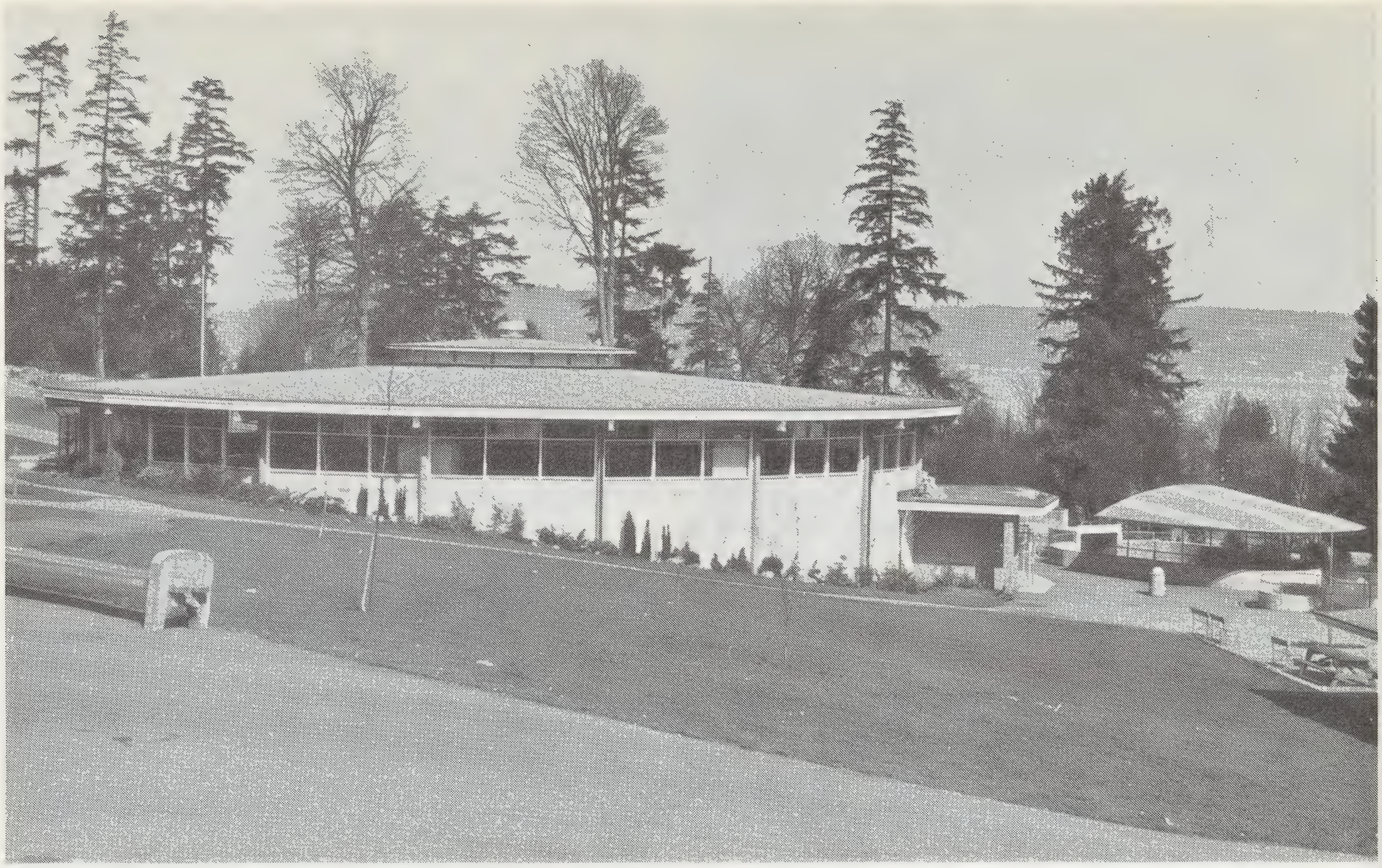
Once inside the main lobby, I approached the first underwater viewing windows of the giant 140,000-gallon circular tank, which houses a cross section of fishes and invertebrates from nearby Puget Sound. This tank dominates the entire display at the Point Defiance Aquarium. In fact, the outlines of the building conform to the contours of this enormous indoor "sea." A circular viewing gallery with many underwater viewing windows, surrounds the tank. The subdued light in this viewing gallery permits a spectacular view into the brightly-illuminated tank.

As I walked from window to window there were large schools of blue striped perch, *Embiotoca lateralis,* grazing over the large reef built up in the center of the tank and picking among the delicate sea anemones and the curious many-rayed starfishes. Spiny dogfish, *Squalus suckleyi,* swam lazily overhead, while a bocaccio, *Sebastodes paucispinis,* remained motionless under the protruding edge of the reef. Several enormous Chinook salmon, *Oncorhynchus tshawytscha,* swam by a window, a fisherman's dream! As they disappeared in the distance some sable fish, *Anoplopoma fimbria,* cruised slowly over the reef. Suddenly this complacent picture of peace and harmony was interrupted. A thick cloud of silvery herrings dashed through the water with a black rockfish, *Sebastodes melanops,* in hot pursuit for its daily meal (as it turns out, locally-caught herrings are added regularly to the tank as food for the predatory fishes).

As I stood there absorbing all the fascinating underwater life, the public address system announced a diving demonstration in the tank. A large crowd hurriedly assembled along the many viewing windows in excited anticipation. On a ladder, suspended from above the water's surface, a helmeted diver entered the water, step by step, clumsily working his way downward. By the time he had reached the bottom, hundreds of fish had congregated around him in expectation. From a sack the man started to hand out small pieces of fish, which created an immediate feeding frenzy, submerging the diver in a silvery cloud of fish bodies. The gregarious shiner seaperch, *Cymatogaster aggregata,* were the most aggressive feeders, fighting almost continuously over even the smallest pieces of food. Seemingly out of nowhere appeared a five-foot-long wolf eel, *Anarrhichthys ocellatus,* approaching the diver with slow, sinusoidal swimming motions of its elongated, snake-like body. Its strong, conical teeth ripped into a large chunk of fish offered by the diver, and the animal swam out of sight again.

Suddenly there was an outcry of horror by the crowd. Like a huge monster descending upon its innocent prey, a giant octopus settled right on top of the diver. Without panicking, the diver gently, but with firm movements, manipulated the large animal so that the viewers on the outside could get a good look at it. The octopus, obviously accustomed to such treatment, did not seem to object. Once rewarded with a piece of fish for its superb "performance," the animal retired to its cave under the large reef in the middle of the tank.

A gurgling chain of air bubbles from his helmet trailing him, the diver moved along in front of the many viewing windows. Children, their faces pressed against the thick glass, observed with awe every movement of the man in the water. As he walked along the diver picked up off the bottom some starfish, a prickly sea urchin, and a bright red sea cucumber and brought these invertebrate animals over to the windows for a closer inspection by the visitors on the outside. Taking the last few pieces of feed from his bag, the diver engaged in a lively tug o' war with some pile perch, *Damalichthys vacca,* which seemed to have inexhaustible appetites. Eventually the diver completed his walk around the tank and approached the ladder again. With slow and deliberate steps he



The Point Defiance Aquarium nestles against the gently sloping hillside, a park setting for a building devoted to the display of the marine life of Puget Sound.

worked his way upward toward the surface and soon disappeared from the view of the spectators.

By following the diver around as I walked from window to window, I too had completed my walk around the big circular tank, and thus I turned my attention to the remaining exhibits of the Point Defiance Aquarium. To compliment the dominant and powerful theme created by the "miniature indoor ocean," there are 38 smaller tanks, also arranged along the main viewing gallery, but opposite the circular center tank.

Over the rocky cliffs in one tank, some spectacular sunflower sea stars, *Pycnopodia helianthoides,* spread their many arms in a continuous search for food, but kept clear of the spiny weaponry of some green sea urchins. In the next tank the graceful undulating swimming motions of some ratfish, *Hydrolagus colliei,* attracted my attention. A label above this tank explained that the strange appearance of this fish has caused it to be named "chimaera," after the ancient monster with the head of a lion, the body of a goat, and the tail of a serpent.

Further on down the gallery was a community tank of sculpins (Family Cottidae). I found myself absolutely intrigued by the delightful grunt sculpin, *Rhamphocottus richardsoni,* as it "hobbled" along the bottom on its specially-adapted pelvic fins. Up in one corner, pressed tightly against a rock, was a strange looking fish, which seemed to sport a "sail" for a regular dorsal fin. This was a sailfin sculpin, *Nautichthys oculofasciatus,* with its elongated, sail-like dorsal waving in order to maintain its balance. In a restless to-and-fro swimming pattern, very uncharacteristic of sculpins – most of which are typical bottom dwellers – the silver spotted sculpin, *Blepsias cirrhosus,* cruised continuously along the front glass of the tank in dizzying circles. Few fishes have such a descriptively well-suited name as the buffalo sculpin, *Enophrys bison,* with its extended "horns." Actually these "horns" are particularly well developed and powerful opercular spines, protruding backward from the upper portion of the gill area.

Another tank features bright yellow sea pens, *Leioptilus guerneyi,* which are closely related to the colorful sea anemones. The lower part of their bodies is buried in sand. Also "scouring" through the sand were some large moon snails, *Polinices lewisii,* with their antennas and syphons reaching above the sand. Hermit crabs, *Pagarus spec.,* were particularly abundant in one of the smaller tanks. Also occupying smaller quarters were some bottom squids, *Rossia pacifica.* Resting on the bottom, this tiny mollusc resembles an octopus. However, once disturbed the bottom squid suddenly will take off with the typical swimming motion of a regular squid.

The largest clam in Puget Sound is the geoduck, *Panope generosa.* This species may reach a length

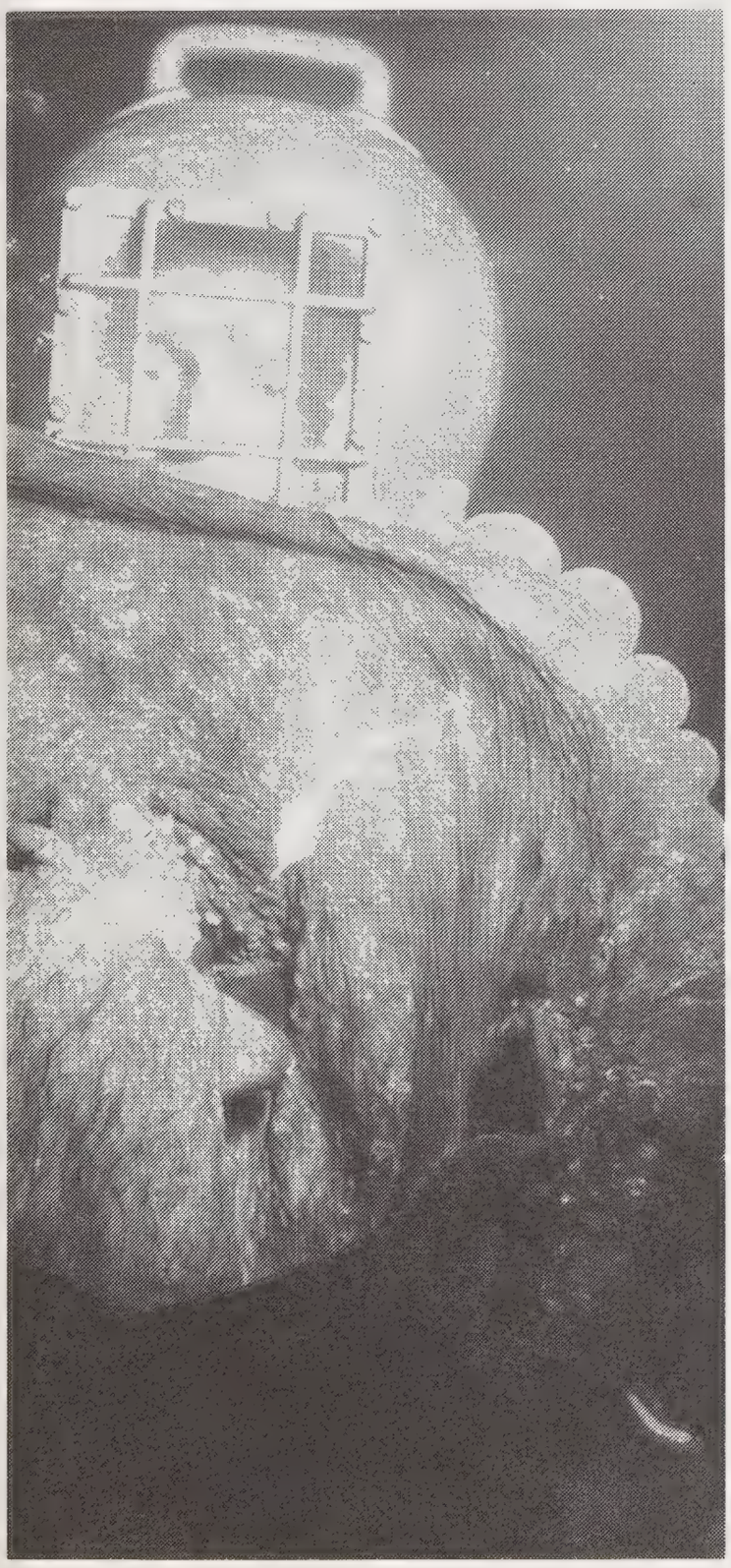
of more than nine inches and a weight in excess of four pounds. Normally this mollusc lives buried several feet deep in the mud, but at the Point Defiance Aquarium they are displayed so that visitors can see the entire animal. Over in another tank there was a display of pink scallops, *Pecten hericius.* A unique jet stream mechanism enables this mollusc to "take-off"—to propel itself through the water by "flapping" its two shells and thus creating a forward thrust by expelling the water toward the back.

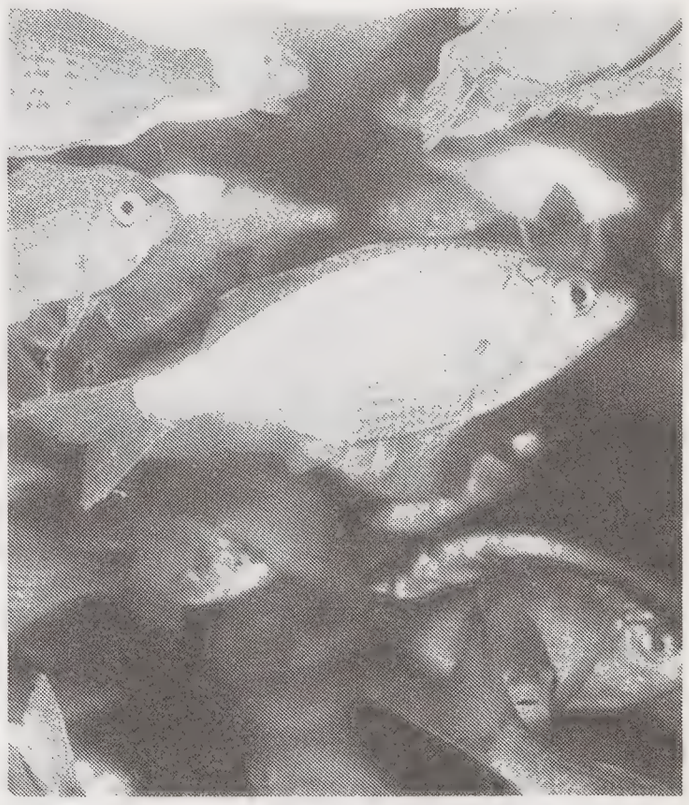
A stairway leads to the second floor, which is essentially the upper deck for the large circular center tank. Looking over the immense body of water, only then did I become fully aware of the enormous size of this "indoor ocean." Down below I saw the tremendous multitude of fishes that live on display in this tank. Just as I turned back from the railing surrounding the tank, a large skate, *Raja binoculata,* its wing-like pectoral fins slowly waving in the water, plowed its elongated snout through the water's surface. A few ripples propagated in ever-increasing circles toward the edge of the tank as the animal submerged quietly.

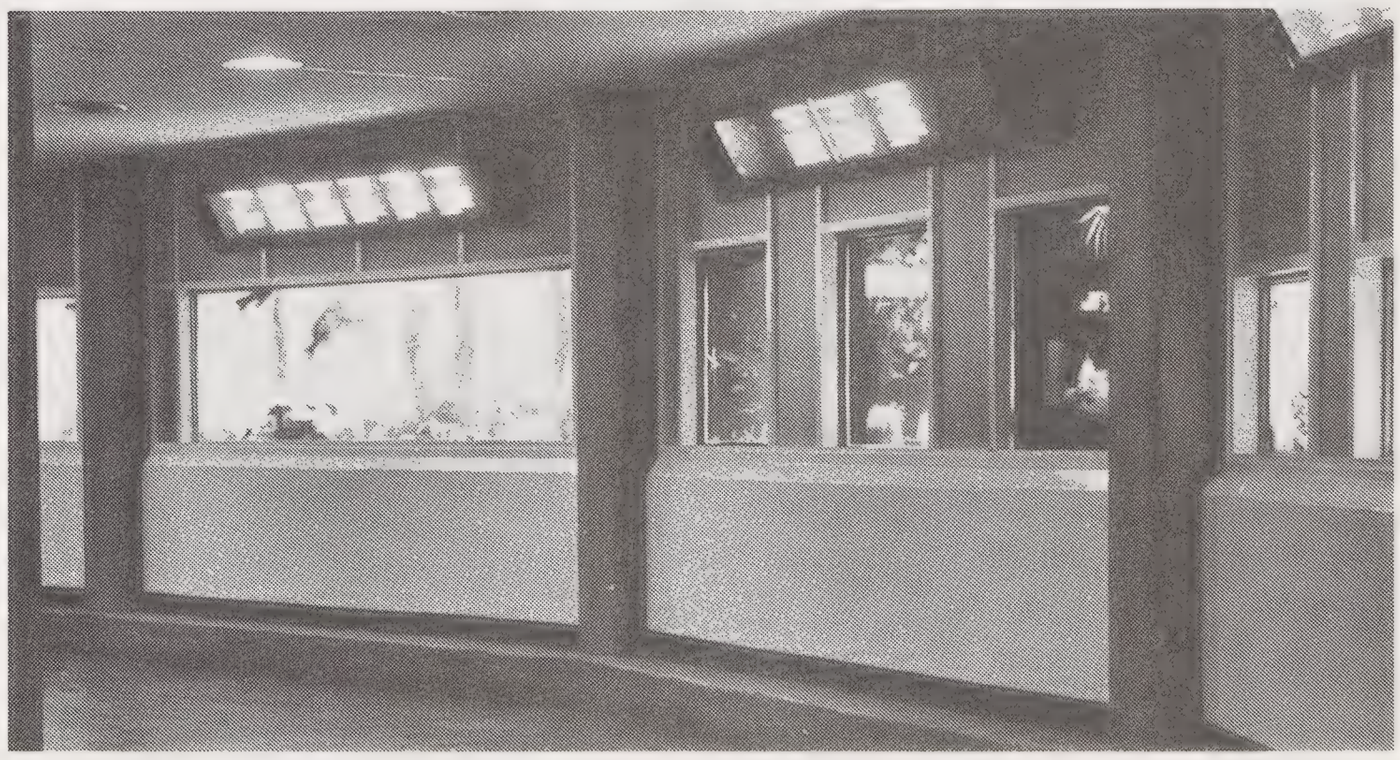
An attractively-designed guide book, available at the aquarium sales counter, gives some of the historical development of this unique aquarium. The Point Defiance Aquarium had its start in 1936, when the Metropolitan Park Board decided to establish a small public aquarium displaying Puget Sound marine life. A park pavillion near the water served as the aquarium building. Eventually the old location near the water became inadequate, and a larger, more elaborate aquarium was needed. The new facility was constructed at a cost of $350,000, within a special millage program approved by the local voters in 1960. It opened its doors to the general public in 1963.

On my way out of the aquarium I took special care not to miss "Gus," the aquarium's lovable sea otter *(Enhydra lutris).* This animal was obtained in 1965 through special efforts of United States Fish and Wildlife Service biologists, through the courtesy of the Laboratory of Radiation Biology, University of Washington. Since sea otters are strongly protected by wildlife agencies, "Gus" is one of the very few sea otters currently in captivity anywhere in the world.

Below, left: octopus and diver. Below, center: hermit crab and shell. Below, right: shiner seaperch. Below, lower right: main gallery of the aquarium.







Thorny Devil

by Terence Boylan

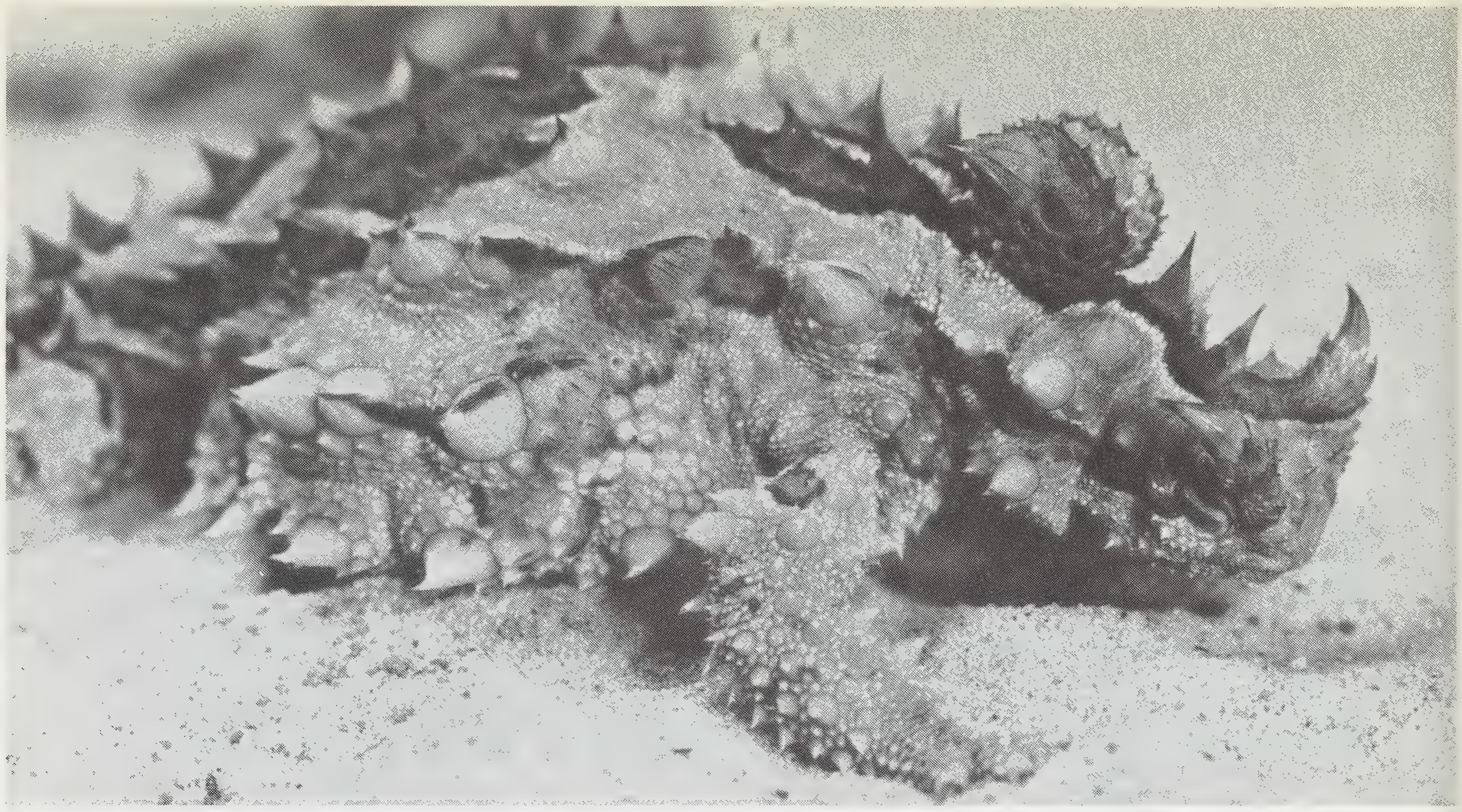
Australia has a rich and diversified reptilian fauna. Like many mammals, birds, fish, and amphibians of this continent, many Australian reptiles have evolved remarkable adaptations in structure, physiology, and behavior which enable them to successfully occupy rather specialized ecological niches.

Some of the most unusual Australian reptiles belong to the family of lizards known as the Agamidae. Agamids are found throughout much of the world, including southern Europe, Africa, Asia, Malaysia, New Guinea, and Polynesia. Australia has approximately 40 species of agamid lizards, which are most abundant in arid areas. However this is not as restrictive a range as at first may appear, since dry topography constitutes 70 percent of Australia's land mass.

The agamid genus *Moloch* has only one living species, known by the rather formidable scientific name, *Moloch horridus.* The horny aspect of this lizard gave rise to the local names of thorny or mountain devil; its scientific name was prompted by its supposed semblance to the Semetic diety Moloch, devourer of children. Far from being either ghoulish or devilish, the Moloch lizard is completely inoffensive and docile; it will harm nothing but ants, for these are the exclusive diet of this remarkable lizard.

Found in dry and semi-arid areas of all the Australian states except Victoria and Tasmania, the thorny devil is seldom exhibited in zoological gardens. Captives almost invariably succumb to starvation in a matter of months. This is induced by their refusal to eat mealworms, cockroaches, and grasshoppers, the usual food items offered to agamids. Ants seem to be the only food items eaten by the thorny devil, and this is reflected by the lizard's specialized teeth and weak jaws.

At Taronga Zoological Park, Sydney, we were able to keep a specimen on display in the reptile department for 22 months—a zoo record. To keep the thorny devil alive, the Taronga Zoo had to provide a sufficient supply of the right kind of



The spiked hump on the Moloch's neck, once thought to be an accumulation of stored fat, is now believed to be purely for defense.

ants to satisfy the lizard's needs. At times, particularly during the winter months, this was not a simple task. The zoo also provided an environment for the lizard as similar as possible to that in which it survives in the wild.

Because of its shape and color, the thorny devil seemed unusual to zoo visitors, but these two factors are vitally important in regard to the animal's survival. *Moloch horridus,* sand-colored, with an average length of only six inches, is difficult for a predator to distinguish because its shape and color pattern blend into the dry surroundings of its environment. On more than one occasion I had noticed members of the public pass the Moloch vivarium under the impression the cage was empty, so well had the lizard merged into the simple background without actually concealing itself.

Reptiles, after the insects, have been the most successful colonizers of the hazardous environment of Australia's arid regions. As a result many Australian reptiles have adapted complex behavioral, physiological, and structural patterns to help them survive this harsh habitat. *Moloch horridus* is no exception, and its hard, spiked skin has another use besides the primary one of defense. It is this additional use that makes the lizard so unique. For a long time it was thought the thorny devil had a very permeable skin and therefore could absorb water directly through its epidermis. Further studies carried out at Western Australian University by scientists P. J. Bentley and W.S.C. Blumer, showed that this is not true. They discovered that water actually moved along minute open channels on the surface of the lizard's skin by a process known as capillary action. *Moloch horridus* is able to draw up and swallow water via the surface of its skin in the same way moisture is drawn up from the soil to be evaporated near the surface.

When any part of the lizard's body is immersed, or just touches the surface of water, the colors of the lizard immediately darken. As the water spreads across the surface of the skin, its entire body becomes saturated within a short space of time. It has now only to continue swallowing to enable the flow to keep moving, and it is a humorous and intriguing sight to watch our thorny devil satisfy its thirst by standing quite still in its shallow water dish.

Droughts are not uncommon in inland Australia, and because they decrease plant life, all food resources decrease. It was once thought that the spiked hump on the Moloch's neck was an accumulation of fat, on which it could depend to offset the effects of drought. The knob-tailed gecko *(Nephrurus laevis),* found in the same environment, utilizes the fat storage from its turnip-shaped tail during lean times.

It is now believed that the horny projection on the Moloch's neck is used purely for defense. This was demonstrated by our zoo specimen. Whenever molested it lowered its head so that the large spines over the eyes were directed forward, and arched its back and neck so that the hump became even more prominent.

On April 9, 1967, a pair of thorny devils was

donated to the Taronga Zoo reptile department by tourists who had collected them in the Northern Territory. Every day both lizards were placed beside a trail of ants, which began to disappear rapidly as the sticky, mucous covered tongues of the reptiles flicked in and out. In such a manner they daily consumed from 250 to 600 ants during a two-to-three-hour period.

It was soon noticed one of the Molochs ate at a slower rate than the other, and three months later during winter it died, from probable lack of food. The hump on its neck showed no decrease in size.

During the remaining winter months, the problem of feeding was partly solved by placing our remaining specimen in a heated squirrel monkey enclosure, where ants occasionally gathered to feed on fruit scraps. While any other small lizard would have been speedily despatched by the omnivorous monkeys, they kept their distance from the Moloch. Twittering loudly as they stood on their legs, the monkeys peered anxiously, but none would come within 10 feet of the lizard.

It occasionally has been stated that a captive *Moloch horridus* will eat a substitute diet but we found this not the case with our specimens. Termites, mealworms, and other small insects were all tried without success; the lizards showed little or no interest.

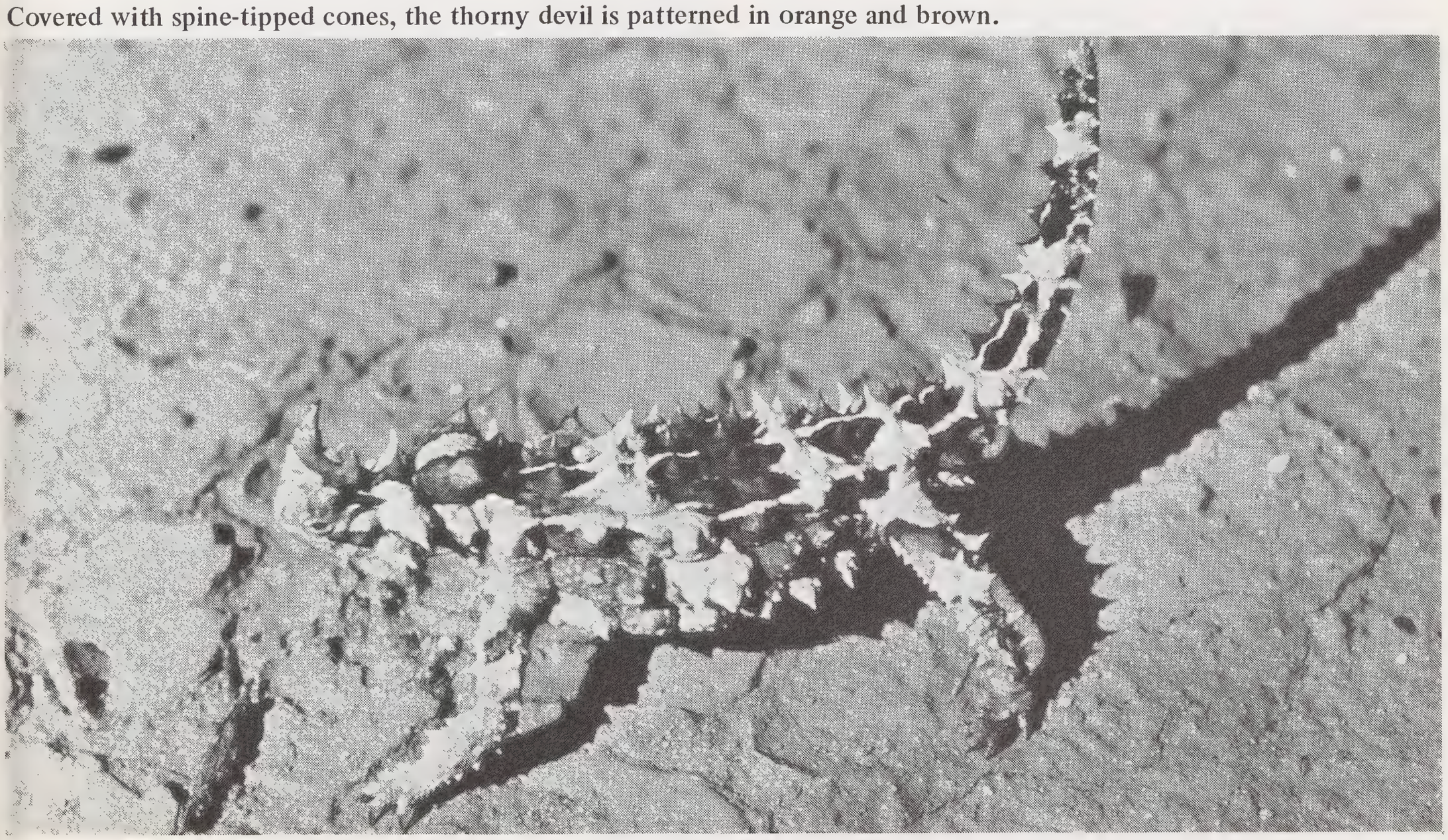
The lizards' coloration, which remained bright under artificial light, almost immediately faded to uniform dirty-brown whenever put out in the sunlight. This is the only color change of which they are capable, and it appears to depend entirely on temperature and light intensity. Perhaps as has been observed in many desert lizards, the lighter skin color is used to reflect the sun's rays, an ideal precaution for an animal that is completely diurnal and lives in inland arid areas. The darker skin color helps to absorb the sun's rays more quickly when the lizard's body temperature is low – for instance, during the cool morning hours. Observations of our specimen suggest that this is so.

The daytime temperature in the lizards' vivarium was kept at about 82°F. but during night hours this was allowed to drop. Nighttime temperatures of 36° to 32°F. and even lower are not unusual in Australia's interior, and to protect itself Moloch retreats into insulated surroundings such as burrows and rock ledges. Since a reptile's metabolic rate slows down with the cooler temperatures, a temperature reduction can be allowed for *Moloch horridus* in captivity, when the supply of ants dwindles.

The ultimate survival of many wild animals hinges on the degree of protection man affords them, and particularly in Australia's arid inland areas, we must look toward the future with this point in mind. The cattle, sheep, and the long-established rabbit that the European brought to Australia with him threaten this finely-balanced environment and its fauna.

It would seem obvious that large national parks are needed to prevent the misuse of Australia's scenic inland and thus ensure that the unique desert creatures, like *Moloch horridus,* will always remain.

Covered with spine-tipped cones, the thorny devil is patterned in orange and brown.



animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

Tropical Asia Exhibit to be Built at Bronx Zoo

New York, N. Y. – A thirty-acre complex featuring the animals of tropical Asia and simulating its environment will be built at the Bronx Zoo, according to plans outlined at the annual meeting of the New York Zoological Society, February 3, at Philharmonic Hall.

Construction of the new exhibit area, designed to reveal to zoo-goers the rhinos, tigers, tapirs, apes, and other animals of the Asian tropics, eventually will cost approximately $10 million. The Vincent Astor Foundation has already pledged $5 million toward its construction.

Commenting on the new undertaking, Mr. Laurance S. Rockefeller, the society's president, said, "No area in the world has a more exciting wildlife or is under greater pressure from environmental destruction than this exciting area which stretches from the Arabian peninsula to Java."

Announcement of the tropical Asia exhibit follows that of a $3 million contribution by Mrs. Lila Acheson Wallace for construction of a spectacular new zoo building, the World of Birds. This building, already under construction and scheduled to open in 1971, "will give the visitor a new feeling for the excitement of the earth's 8,600 species of birds and a new understanding of his own relationship with their world," Mr. Rockefeller said.

In his report to members, Mr. Rockefeller cited the new projects as part of the New York Zoological Society's "unique and special role in the seventies" to meet the need for environmental education and urban recreation. "From the campus to the White House," he said, "there is a new awareness that the environment is crucial to the quality of life and that the time for action is upon us."

The Honorable John V. Lindsay, Mayor of the City of New York, joined New York Zoological Society President Laurance S. Rockefeller at Philharmonic Hall on February 3, for the seventy-fourth annual meeting for members of the society. At the meeting, Mr. Rockefeller paid tribute to the new trustees who were elected during the past year: Mrs. Vincent Astor, Gilbert M. Grosvenor, and Mrs. Lila Acheson Wallace. In addition, members enjoyed an evening with two lion cubs, a Moor macaque monkey named Saki, films, whale sounds, and exhibits from the Bronx Zoo, the New York Aquarium, Osborn Laboratories of Marine Sciences, and Institute for Research in Animal Behavior.

DDT Menace to Marine Animals

Beaufort, N. C. – Studies by scientists at the Duke University Marine Laboratory indicate that the pesticide DDT is a major threat to many important species of ocean animals.

The reseachers say their findings indicate that ordinarily non-fatal amounts of the chemical introduced into estuary breeding grounds may kill off generations of marine animals such as crabs, shrimp, and fish. They point out that not only are estuarine waters in and around river mouths the natural nursery for many marine species, but they also form natural collection points for DDT runoff from inland areas, a factor that compounds the danger.

In a series of studies here over the last three years, four types of crabs were given food containing small amounts of DDT in their early developmental stages. They were not killed outright, but most became abnormal in later stages of development and few survived to maturity.

The researchers say that because of the cumulative nature of DDT, the similarity of developmental processes, and the inter-relationship of the marine food chain, the findings indicate a clear danger to other marine animals such as shrimp and fish. Moreover, the studies show that one of the two major sources of the chief food used worldwide in laboratory rearing of marine animals is contaminated with enough DDT to interrupt the life cycle.

The research was conducted by Dr. C. G. Bookhout, acting director of Duke's oceanographic program here, and Dr. John D. Costlow, director of the Marine Laboratory.

"Our studies indicated that DDT is a threat to estuarine larvae of crabs, shrimp and all fish and that if DDT levels in estuaries continue to increase we are in serious trouble," Dr. Bookhout said.

The studies began about three years ago with an observation about brine shrimp – tiny, shrimp-like creatures that are the most widely used food in rearing marine animals such as crabs and fish. The creatures, familiar to most household aquarium keepers, are found in highly concentrated salt waters. Dried brine shrimp eggs can be bought in cans and hatched in warm water.

According to Dr. Bookhout, the two principal commercial sources of brine shrimp are salt-water ponds near San Francisco, California, and the Great Salt Lake of Utah.

Investigators here and elsewhere noticed that crabs reared on brine shrimp from California seemed to have a far greater chance of survival than those reared on Utah brine shrimp. On the basis of this, Bookhout and his colleagues began a series of controlled studies in an attempt to explain what was happening.

Four types of crabs, two of them estuarine mud crabs and two oceanic varieties, were fed brine shrimp from the two sources from the time they hatched from eggs. After hatching, crabs go through several development stages in which they are called larvae. They then reach the megalops stage just before becoming juvenile crabs.

The two types of mud crabs fed with California brine shrimp mostly reached the juvenile crab stage without incident. When fed Utah brine shrimp, however, none lived to the first crab stage. Many of them did reach the megalops stage, but they were largely abnormal, and indication, says Dr. Bookhout, of the dangerous cumulative effect when small amounts of DDT are introduced into the breeding grounds of marine organisms.

The pesticide is a long-lived one that accumulates in animal tissue.

In tests on the oceanic spider crab, survival to the megalops stage was high among animals fed brine shrimp from both sources. However, only five percent of those fed Utah brine shrimp reached the first crab stage as compared to 63 percent fed from California sources.

In tests with the commercially important blue crab, 50 percent of the specimens fed with California brine shrimp and 31 percent fed Utah brine shrimp reached the megalops stage. Survival to juvenile crab stage was 34 percent with California brine shrimp and only 24 percent with Utah brine shrimp.

In examining the abnormalities that appeared in early developmental stages, Bookhout and his colleagues noticed that they were typical of DDT poisoning. Laboratory tests showed that the Utah brine shrimp contained about three times as much DDT (7,050 parts per billion) as the California specimens (2,300 parts per billion).

The Duke marine biologist said that the difference in DDT content may be because the Great Salt Lake drains a far larger area and is thus subject to greater pesticide runoff from adjacent lands. He pointed out that because of the step-by-step progression in the marine food chain, even small amounts of DDT runoff could prove disastrous to marine organisms over a period of time.

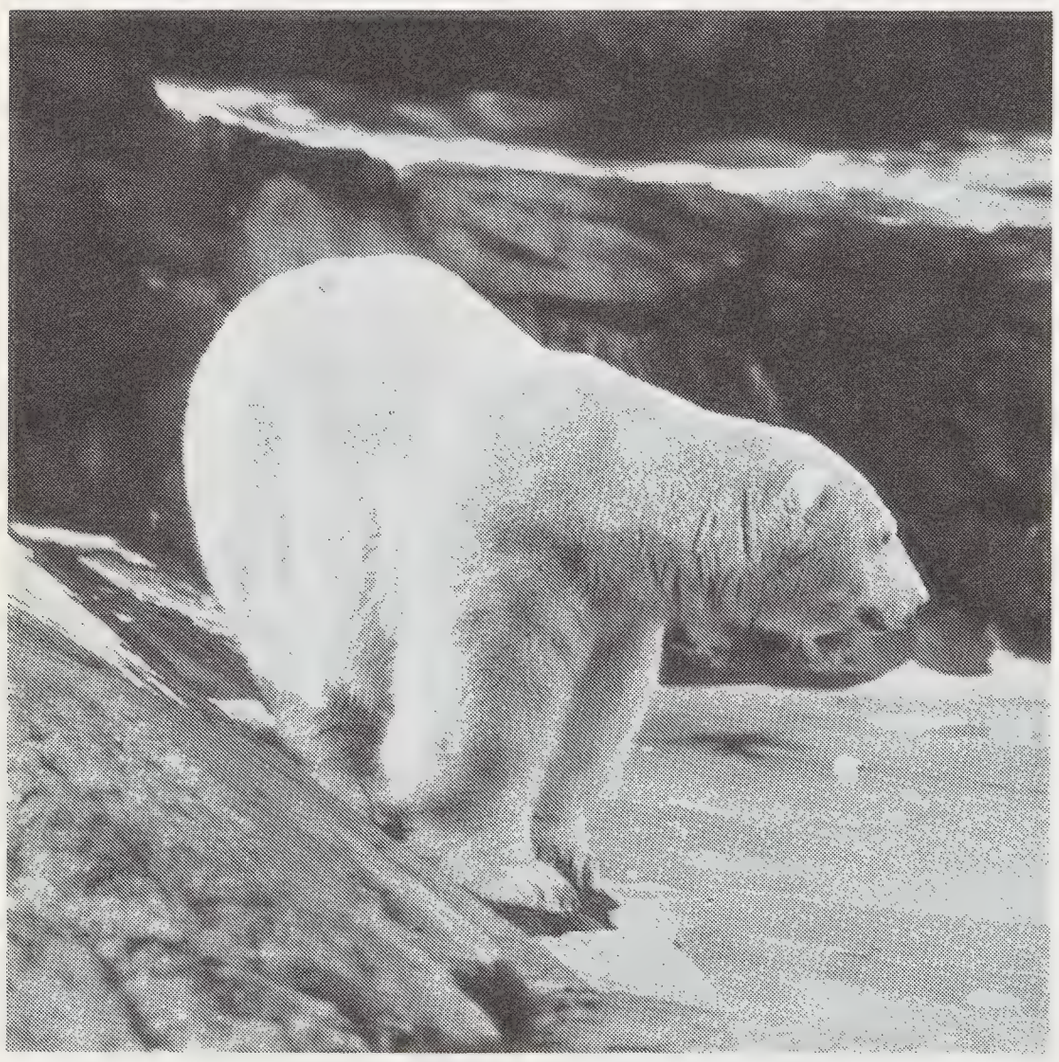
Polar Bear Specialists to Meet

Morges, Switzerland – Specialists in polar bears, the great free-ranging carnivores of the Arctic, will gather in Morges February 2 to 4, 1970, to review research and conservation progress and to co-ordinate plans for the next two years' study of the depleted populations of these animals.

The meeting is sponsored by the International Union for Conservation of Nature and Natural Resources which, since the First International Conference on Polar Bears in 1965, has had responsibility for collating scientific research date on the polar bear.

Experts from the five circumpolar nations – Canada, Denmark, Norway, the USA, and the USSR – will attend the working meeting. The same group met at IUCN's Morges headquarters in January 1968, at which time the scientists compared data and took steps to launch the co-operative research program.

Although hunted commercially since the 17th century, polar bears have been favored by their remote and inhospitable habitat and remained relatively abundant. In recent decades, however, their number has declined rapidly because of excessive hunting and changes in their habitat. While their remaining numbers can only be estimated roughly, fewer than 15,000 in all are thought to exist. More accurate methods of counting and the filling of large gaps in knowledge about the ecology of the white bears are among the objectives of the research program.



The polar bear *(Thalarctos maritimus)* is a vanishing species. The bears are so extensively hunted – nowadays from airplanes and helicopters – that conservationists are much concerned about their survival. Russia, but not the United States, has accorded the polar bear full protection.

The polar bear has been totally protected in the USSR since 1960. It is also protected in reserves on King Karl's Land (Norway), James Bay (Canada), and Wrangel Island (USSR). Cubs and females with cubs are protected throughout much of the animals' range.

During most of the year, many bears range on the pack-ice beyond territorial boundaries, hence the need for international co-operation in their protection.

Scientists Study Fish Farming

Kingston, R.I. – Marine scientists at the University of Rhode Island are raising fish in captivity, in much the same way as farmers raise chickens.

"We are trying to raise protein intensively in sea water," Dr. Saul Saila, U.R.I. marine biologist and director of the new project, explained. It is an experiment in aquaculture – fish farming.

The aquatic version of the chicken coop is a group of plastic-lined pools containing sea water. The "farm" is the URI Marine Experiment Station on a 200-acre site not far from the Atlantic Ocean and the entrance to Pt. Judith Pond at Jerusalem, Rhode Island.

The station, which now includes two wood frame buildings and six pools with associated pumping, piping, and storage facilities, was established with the help of federal Sea Grant College funds and a foundation gift. Land is provided by the R.I. Department of Natural Resources at no cost to the University. There are facilities for hatching, rearing, and holding fish.

Researchers are pleased with the progress of the experiment, which began in the spring of 1969. "Our limited experience with the system under development is very encouraging," Dr. Saila said.

He explained that in one experiment at the station, researchers succeeded in raising Atlantic salmon from an average weight of 1.5 ounces to a size of nearly 12 ounces in six months under relatively poor growing conditions. "We are convinced that with better environmental controls, it will be possible to effect even more growth than observed to date," he added.

Dr. Saila is concentrating on the so-called luxury fish, including rainbow trout, salmon, bluefish, and striped bass. Simultaneously, the Department of Food and Resource Economics at URI has begun studying marketing aspects of fish farming, but Dr. Saila anticipates few problems in this area, since there already is an extensive market for high-quality trout and salmon. He said he

believes the fish can be produced more cheaply through aquaculture than through commercial fishing.

Fish used in the project have been spawned in fresh water, some in captivity. They later are transferred to the outdoor salt water tanks. Dr. Saila explained that one of the major problems in fish farming is to determine at what size and age the fish can be transferred to salt water. The fish grow faster in sea water, and there is less disease.

All the fish being used in the experiments normally must spawn in fresh water. The project fish, however, will remain in salt water. When they are ready to spawn, the reproductive systems and eggs will be removed from the fish, and the eggs will be fertilized artificially. The eggs then will be hatched in fresh water in the experiment station.

One problem is to keep the sea water at the proper temperature for the fish. Dr. Saila said the water must be cooled slightly during a portion of the summer and heated somewhat during winter. He is developing an underground water supply to temper the sea water.

There are several other fish farming experiments in progress. The University of Miami is working with shrimp and pompano, and in Norway, rainbow trout are farmed for food.

Fish farms may never be as common as chicken farms, but Dr. Saila believes aquaculture will become "a relatively important business venture."

THE bookshelf

A WALK THROUGH BRITAIN. *By John Hillaby. Woodcuts and maps by Margaret Webb. 278 pp. Houghton Mifflin Company, Boston, 1969. $5.95.*

There is nothing like having definitive starting and stopping points for a walk; England has the classic ones of Land's End and John o' Groats. Even our Appalachian Trail of 2,000 miles from Mt. Katahdin in Maine to Springer Mountain in Georgia leaves plenty of unwalked country at either end, but in Britain you can go no further north or south. In a country where walking the bounds of private or parish lands is an ancient custom, many have been tempted to span the whole country and, as Mr. Hillaby mentions, somebody even pushed a pram the whole length of England and Scotland.

It is what you see, what you experience, what you learn, and what you have the imagination to tell about your walk that count, of course, and Mr. Hillaby is a perceptive walking companion who shares his small adventures, his discoveries, and his feeling for the history he is traversing. He came to the end of his 1,100-mile journey with "a sense of gradual transition from one place to another, a feeling of unity. The mosaic of my own country and its people had become a sensible pattern." That, unfortunately, is not one of the rewards of exploring a country by automobile at 80 miles an hour. Walking is still the best way of getting more than somewhere else.

William Bridges

THE YEAR OF THE WHALE. *By Victor B. Scheffer. 213 pp. Charles Scribner's Sons, New York, 1969. $6.95*

This is a delightful story about the ventures of a mother and baby sperm whale over a year's period. It is a fine treatise of natural history written in magnificent prose. The life history of the sperm whale unfolds effortlessly and pages are interspersed with interesting facts about cetaceans.

Most important is the message carried concerning man's exploitation of nature – the blunders he has committed and will continue to commit.

This book is a must for layman and scientist both young and old.

Robert A. Morris

ANIMAL MECHANICS. *By R. McNeill Alexander. 346 pp. University of Washington Press, Seattle, 1968. $9.50.*

This is a very helpful book that brings together zoology with the mechanics and engineering of physics.

The title of the book is completely descriptive as it really deals with the mechanics of animals. The topics discussed range from the mechanical advantage of bone articulations and muscle attachments to the mechanics of sound, balance, and vibrations. The title of each chapter gives a good indication of its contents. Force, energy, elasticity, viscosity, strength, motion, pressure, density, and surface tension are some of the other topics discussed.

The few diagrams in the book are quite useful. One other good feature is the fact that a variety of animals are considered, including both vertebrates and invertebrates.

This book makes many of nature's structures and mechanisms much easier to understand, and it gives a great deal of insight into the mechanics and engineering of living organisms.

Animal Mechanisms should be a welcome addition to any zoologist's library and it is a handy reference for every zoology student.

Donald Bruning

MAN AND MONKEY. *By Leonard Williams. 203 pages with black-and-white photographs. J. B. Lippincott Co., Philadelphia, 1968. $5.95*

This is a humorous and sympathetic account of the care and antics of a captive group of South American woolly monkeys living with the author and his family on the Cornish coast. The narrative style is always evocative and amusing, the accounts ranging from fantasy conversations between author and simian friend to good descriptions of social, breeding, and parental behavior. A disappointment in this volume is the generally poor quality of the photographs, especially considering the opportunities which must abound at the sanctuary.

Although he often lambasts scientific methodology, Mr. Williams sometimes shows a real talent for it in his descriptions and behavioral experiments. More often though, his emulations of objectively fail miserably as he hopelessly confounds observation with inference, deduction with speculation. This can be easily forgiven as the general reader will not be persuing this book for comparative data on primate behavior; no harm is done as long as the non-specialist is not bedazzled by the aura of scientific authenticity clinging to some of his statements, and the reader must not credit as necessarily valid the highly irregular generalizations from woolly monkey to human behavior.

It is easy to sympathize with the author's stern views on greedy and unscrupulous animal dealers and his scoffing at over-protective parents who shuttle their children away from seeing monkey sexual behavior because it is "not natural." This book's value and interest lie in such unveilings of Mr. Williams' philosophies and the manner in which intimate life with another primate species has helped shape them.

Steven Green

THE AUDUBON ILLUSTRATED HANDBOOK OF AMERICAN BIRDS. *Edgar M. Reilly, Jr. 544 pp. McGraw-Hill Book Company, New York, 1968. $25.00*

This book, sponsored by the National Audubon Society, is exceedingly spare on full-color photographs for a book of its price; only 35 of the more than 400 photos are in color. There is little else that can be said against the book. It is extremely useful for the novice birder, providing accounts of every species of bird found north of Mexico – some 875 species in all. The book is arranged according to family in systematic sequence. The individual accounts contain the following sections: appearance, voice, range and status, habitat, seasonal movements, and biology, in addition to notes on suggested reading.

Editor of the book was Dr. Olin Sewall Pettingill, Jr., director of Cornell University's Laboratory of Ornithology. The author is curator of zoology at the New York State Museum. A hundred drawings by Albert Earl Gilbert add to the book's illustrative content.

E.R.R.

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DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

Black-footed Ferret

Mustela nigripes

Audubon and Bachman were the first to describe the black-footed ferret in 1851. Some doubted their description since it was more than twenty-five years before the animal was reported again.

One of the rarest mammals in North America, the black-footed ferret is the North American representative of the Old World polecats. It is the largest member of the genus *Mustela* in North America. The black-footed ferret is distinguished from other weasels by its size, pale yellowish-brown color, and black mask, feet, and legs.

Little is known of the history or habits of this uncommon mammal. In the past, this could be attributed to the ferret's very secretive nature, but today it can also be credited to the scarcity of the animal. At one time it appears to have been abundant from the Great Plains of Alberta and Saskatchewan in Canada south into Texas and Arizona. This range is almost identical with that of the black-tailed prairie dog.

The black-footed ferret depends on the prairie dog as a major food source. There is little doubt that the ferret can and presumably does prey upon other small mammals and birds.

An evacuated burrow in a "prairie dog town" is the ferret's usual abode. From this convenient center it hunts the other inhabitants of the town. Its slender shape allows the ferret to snake with ease through the tunnels in pursuit of prairie dogs.

The sad history of the black-footed ferret differs little from that of so many rare wild animals. Man's greed and ignorance has directly or indirectly caused the reduction of the black-footed ferret, as well as of many other North American mammals.

For many years it has been the practice in this country to attempt to eradicate animals that may be a threat to agriculture. The federal government and state and local governments allow the elimination of many of our native mammals through predator control, pest control, and bounties.

Ironically, in the case of the black-footed ferret, it has been pest control of the prairie dog as well as habitat destruction that has been the downfall of the ferret. Black-tailed prairie dogs once lived in towns that often covered hundreds of miles and housed many thousands of individuals on the grass-covered plains. The introduction of cattle and the cultivation of the soil made the prairie dog a menace to ranchers and farmers because of its presumed consumption of grass and crops. The spreading of poisoned grain where the prairie dog was to be eradicated brought about its rapid extermination in many areas. Where the black-tailed prairie dog once numbered in the hundreds of millions, it is nearly extinct today. Parallel to this disappearance was that of the black-footed ferret. Its decline may be attributed to the loss of its main source of food, to the ruination of its habitat, and to the fact that some ferrets may have died as a result of eating prairie dogs that had been poisoned.

Today the black-footed ferret is on the verge of extinction. It is a protected animal in some states, but what is needed is strict legal protection for it and the black-tailed prairie dog in every state they inhabit and the preservation of their grasslands habitat.

James G. Doherty

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MAGAZINE OF THE NEW YORK ZOOLOGICAL SOCIETY VOL. LXXIII NO. 2 APRIL, 1970

ABOUT THE COVER

Front: Black rhinoceros *(Diceros bicornis).*
Tough and truculent, the black rhino is one of Africa's most spectacular animals. It is also in danger of extinction. One of the last strongholds of the black rhino is the Tsavo National Park in Kenya. Biologist John Goddard reports on his studies of the black rhinos of Tsavo (see page 2).

Back: Nassau grouper *(Epinephelus striatus)*
is a tropical fish of the western Atlantic Ocean; adults are primarily reef dwellers.

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SMITHSONIAN
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BLACK RHINO OF TSAVO

by John Goddard

The tiny Super-Cub aircraft roared over the top of the *Terminalia* bushes amid the arid scrub of Tsavo National Park in Kenya. A huge black rhinoceros lumbered out from the bushes and trotted down the edge of a small rocky ravine, following the contour of the slope. Tiny tick birds fluttered around the rhino's head, as it carefully weaved its way through the patches of thorn-bush. The rhinoceros finally came to a stop in the shade of an umbrella acacia, swinging its head quickly from side to side, as though trying to locate the source of the disturbance.

"Any more?" shouted the pilot. "Don't know," I replied, "let's try another pass." Again the tiny airplane roared over the bushes at tree-top level, shot up in a graceful arc, and banked sharply to the left. A puff of dust suddenly appeared from among the bushes. An instant later a female rhinoceros with a small calf, accompanied by an immature rhino, ran out of the thick cover and raced away.

The record and location of the group was carefully noted, and on we flew. Far away the majestic snowcap of Mount Kilimanjaro glistened in the morning sun. The little plane was now flying adjacent to the Galana River and parallel to the Yatta Plateau, a gigantic lava flow stretching for nearly 180 miles across Kenya.

I tapped the pilot on the shoulder. "Something over there," I shouted above the roar of the aircraft, "dust behind that tall termite hill." The plane banked sharply to the right, and we flew over to the termite hill. Several giraffe and a large group of zebra and oryx bounded away beneath us. A very alert rhinoceros was standing behind the termite hill. Disturbed by the noise of the aircraft, he had gotten up from his dust-bed, thus raising the dust and attracting my attention.

On we flew up the meandering Galana toward its junction with the Tsavo. Several more groups of rhinoceros were observed near the rocky Simba hill, scene of the famous "Man-eaters of Tsavo" episode, immortalized by Colonel Patterson at the beginning of this century. We landed for fuel and mapped our results. Sex, relative age of the rhinoceros, group structure, location, activity,

A female black rhinoceros and young calf were among the individuals studied by the author in Kenya's Tsavo National Park, which probably contains the largest population of black rhino in existence today.

habitat type, and other biological date had been carefully noted for each observation. We had seen 87 rhinoceros in one and a half hours. The percentage of calves of the year in the sample was of considerable interest, as this provided an index of recruitment of young animals to the population.

Tsavo is one of the last strongholds of distribution of the black rhinoceros, and the park probably contains the largest population of this species left in existence. The morning's work described above was part of a census of the species which was conducted in Tsavo during 1967-1968.

The park is undergoing progressive change from what was formerly a thick *Commiphora* woodland to bush grassland and open grassland. The change has been initiated by tremendous destruction of this woodland by a very large population of elephants. In some areas, damage to the woodland has been phenomenal. Thousands of trees and larger bushes have been knocked over and destroyed, and many of the larger trees such as the baobab have been ring-barked and fallen to the ground. With the large amount of dead and decaying woody material and debris present, hot ground fires have swept through, aided in their spread by the inevitable invasion of the open areas by grasses. These fires in turn tend to kill off or retard new growth of browse. These two factors have changed the whole ecology of the region. The black rhinoceros is essentially a browser; from the point of view of conservation of the species, it was considered very important to determine the probable effect of this habitat change on the species.

Some observers felt that the large scale devastation and damage initiated by the elephants and aggravated by fire have been detrimental to the black rhinoceros; they believed that the rhinoceros were suffering severe competition from the elephant for the remaining food supplies and that the rhinoceros were slowly dying of malnutrition. This anxiety was heightened in the early part of this decade when, during a marked drought, at least 282 rhinoceros died along a 40 mile section of the Athi River in the eastern sector of the park.

A census of the rhinoceros population was thus one of the concerns of research on the species. Large parts of the park were systematically covered in a Super-Cub, and all rhinoceros seen were counted and recorded on a map. Animals

seen were recorded as adults, immatures, females with calves, and females with young of the year. Black rhinoceros are difficult to detect from the air even in open thorn-bush habitat. Not only are they essentially solitary mammals, but their habit of wallowing and resting in dust-depressions provides them with excellent camouflage in their surroundings. Also, the natural dull color of the animal often tends to match perfectly with its surroundings.

In view of this difficulty, correction factors were placed on these counts and crude estimates of the population made. These crude estimates were then checked and refined by ground counts and by intensive searches of very small sample plots from the air. The crude estimates and refined estimates show close agreement and suggest that the population is around 7000.

One evening a friend arrived in Tsavo. During the course of our conversation, he asked to accompany me on field observations of the rhinoceros. It so happened that I was going out the following morning to obtain further data for the studies of food preferences of the rhinoceros.

We departed the following morning as the pink streaks of dawn were appearing above the thorn-bush. Driving along a red dusty road we rounded a bend. There, 50 yards ahead of us, was a large bull rhinoceros. He was busily feeding on some *Crotalaria* growing in abundance at the edge of the road and was unaware of our approach. I turned off the engine quickly and examined the animal with my binoculars, pointing out its salient features to my companion: the complete absence of a fringe on top of the right ear, a semi-circular notch on the bottom lobe of the left ear, a posterior horn noticeably pointing forward, a small stub of an anterior horn, a prominent and permanent triangular scar on the central left side of the neck. "When he turns around you will see that half his tail is missing," I whispered to my companion. "Its an old male I've seen many times around here."

Black rhinoceros can readily be identified individually by noting their sex, characteristics of the body and ears, by the size and shape of the horns, and by the pattern of wrinkle contours on the snout. Normally when studying the habits and ecology of a wild animal, it is necessary to tag or to mark individuals so that they may be recognized when seen again at some later date. This is not necessary with the black rhinoceros, as is the case with several other African mammals. Their individual characteristics differ very markedly, and as the animal is sedentary, usually occupying a very small home range, subsequent identification is easy. Identification is essential for home range and movement studies, but can also be very useful in other work, such as age-growth rate studies of calves.

We arrived at the Galana River just as the sun was slowly appearing above the majestic Doum palms on the banks of the river. Several small groups of elephants were feeding near the salt-bush which formed a fringe on the river banks. Slowly we drove down-stream parallel to the river. A large herd of buffalo galloped across the road in front of us. As far as the eye could see, the skeletons of thousands of dead trees could be observed, destroyed by feeding elephants during a severe drought. The dead boles and branches were slowly being covered by invading grasses and shrubs.

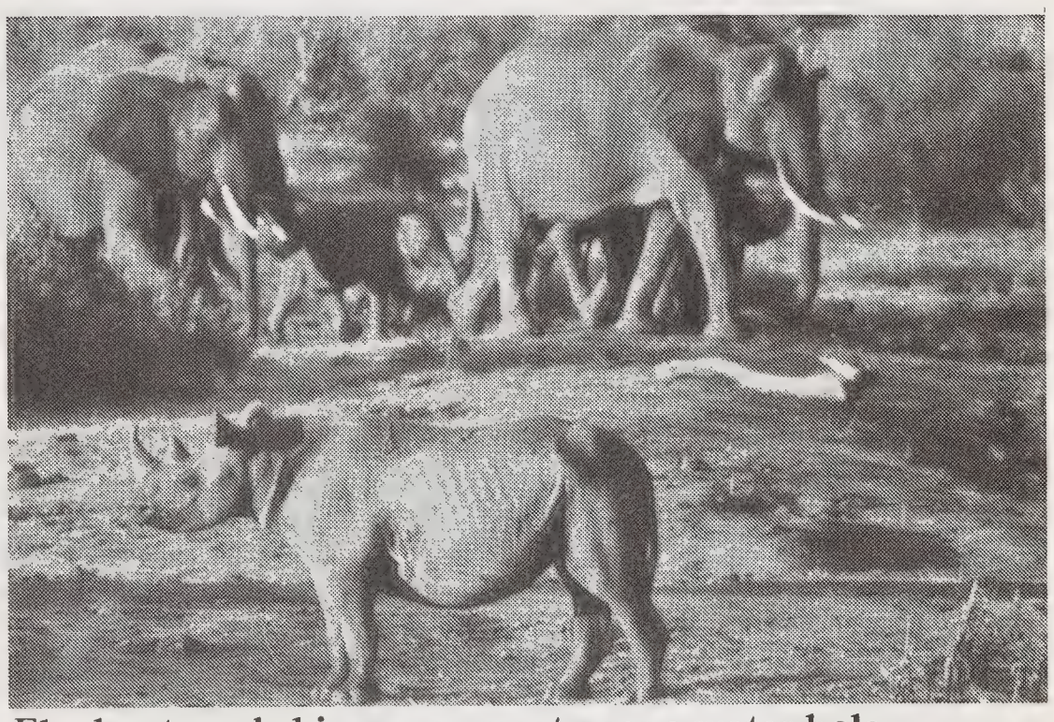
I stopped the Land-Rover. Accompanied by a park scout, we proceeded on foot. The sun was higher and already the air was hot. At about 8:00 A.M. the scout stopped abruptly, turned, and said "Kifaru bwana; kule." An instant later we heard the screech of tick birds. I followed the scout's pointing finger with my binoculars and observed a

The black rhino is not really black, but rather dark gray in color; it has a lengthened upper lip which it uses adroitly in plucking leafy branches (left). An aircraft was used to locate the animals, which would run from cover and away from this disturbance (above).

cow rhinoceros with very long horns, accompanied by a tiny calf. The cow was feeding actively, and every time she stopped to feed, the calf attempted to suckle.

"There's a cow over there with a new-born calf," I whispered to my companion. "We'll go over and watch her feeding." The scout tested the wind and motioned me to follow him. Slowly we approached. Making use of the sparse cover, we stalked to within 35 yards of the rhinoceros. Fortunately she was walking directly into the wind, and the tick birds had left her. These birds often accompany a rhinoceros, and when something unusual approaches, the birds often screech and fly up with loud chirps; the rhinoceros is immediately on the alert. When the rhino is unaccompanied by these birds, it is possible to get very close to it as the rhinoceros is quite short-sighted.

Very slowly we followed behind the cow; note was made of the plants she was eating. The freshly-browsed tips of the plants were very apparent. I pointed to the green specimens of *Indigofera spinosa,* with their neatly clipped terminal shoots. "You can see that she's eating a lot of these ground herbs," I said to my companion. "This is another palatable food," I said, pointing to a freshly clipped *Caesalpinia,* a small bush with beautiful pink flowers which superficially resembles a small acacia. The rhinoceros had carefully



Elephants and rhinoceros meet near a water-hole.

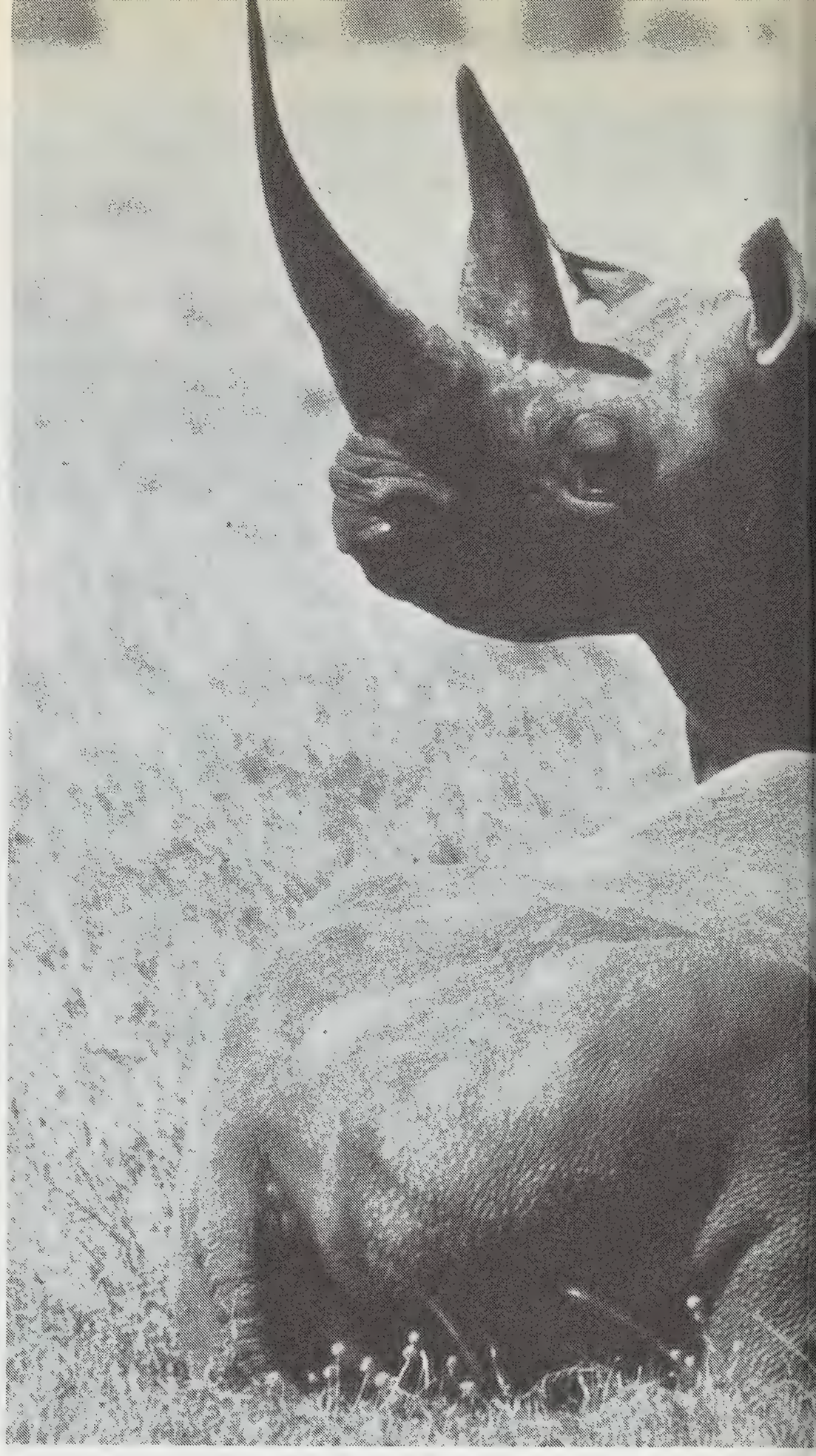
The black rhinoceros is essentially a browser, competition with elephants for browse during periods of drought would be detrimental to the rhinoceros population.

selected the terminal parts of the bush, leaving a straight clean cut, as though snipped with a pair of shears. We examined, noted, and recorded on a check sheet the floral composition and habitat type through which the animal was feeding. It was important to determine the plants which were available to the feeding rhinoceros, in addition to the plants which she actually selected, the latter in order to establish food preferences.

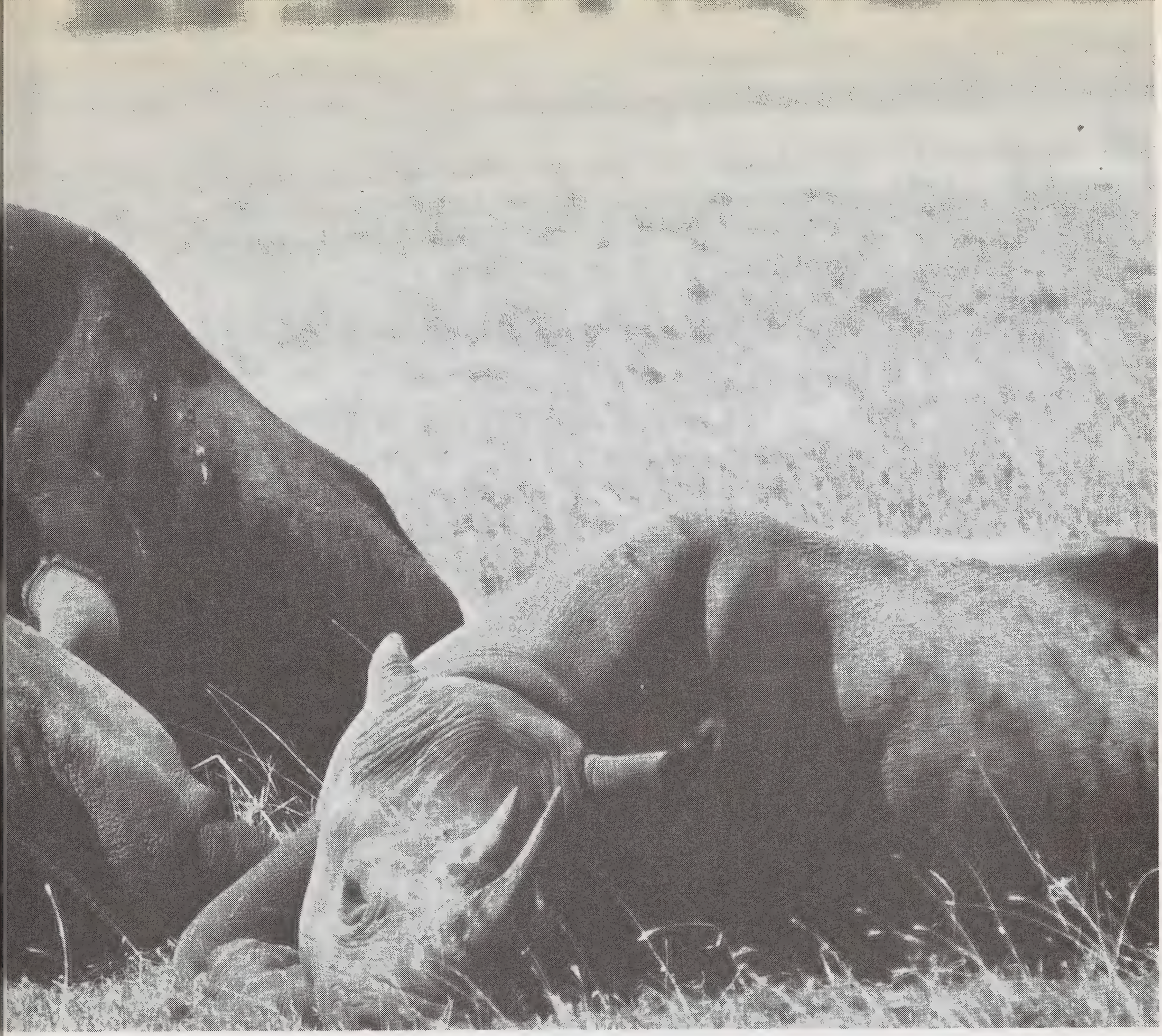
I carefully checked my catalogued records. I had seen this cow three weeks before; at that time she had been accompanied by a very large female calf. Now she had a tiny male calf, born sometime in the interim period. I was very pleased, as the age of this calf was known with some precision, and his growth and development subsequently could be studied. The female rhino may calf every year-and-a-half to three-and-a-half years in the wild. At times the interval is even longer.

The cow was now some distance away standing alongside a termite hill. The calf was butting her udder with his head. A moment later she nudged him away with her hind leg and sat down in the dust-depression adjacent to the termite hill.

On the way back to the Land-Rover, the scout pointed to a white object about 150 yards from the trail. I glanced at it with my binoculars and saw it was a bleached rhinoceros skull lying in the sun. We retrieved the skull and the lower jaw and returned to the Land-Rover. Arriving back at



Tick birds accompanying a black rhino function as a warning system for the weak-sighted mammal.



The two stout horns of the black rhino are formed from closely-packed fibers, sometimes called hair, and have no connection with the bone of the skull.

headquarters I placed the skull with the others in the collection outside the laboratory.

My friend was fascinated by the large collection of skulls which numbered over 500. The approximate age of a rhinoceros can be determined by examining the characteristics of its dentition. Age studies can be very useful in determining the status of a wild animal population; an increasing healthy population usually contains a high percentage of young animals, whereas a decreasing population usually contains a high percentage of old animals. A stable population shows a more even distribution of age classes, and the birth rate equals the death rate.

The collection of skulls had been divided into several age groups. This made it possible to determine the proportional mortality occuring in each class. These studies, together with studies of the age structure of the living population, provided a useful method of ascertaining the status of the population.

The black rhinoceros, like the other four living species in the rhinoceros family, has long been believed to be in danger of extinction. In recent years, considerable concern has been shown by the governments of Kenya and other African nations and by international zoological organizations, which have speculated on the fate of the black rhinoceros throughout its entire range in Africa. There is no doubt that the species is extremely vulnerable to poaching, and the value placed on its horn makes it an attractive target to poachers. It is also unable to adapt to invasion of its habitats by agricultural settlement and other forms of development. In addition, it is very sedentary and shows no tendency to disperse into new habitats. The species is also late in maturing and possesses a low reproductive potential.

It is believed that around 1850 the black rhinoceros occurred in approximately one-third of the land area of Africa south of the Sahara. It's distribution today shows that its range has been reduced considerably, but that it still occupies a substantial part of its former range. It is only very

The black rhino, capable of short burst of speed up to 25 miles an hour in a lumbering, earth-shaking gait, is an unpredictable animal but is more inclined to run away than to charge a man.

recently that scientific studies of the species have been initiated in various parts of Africa. In East Africa these studies have shown that in some areas the species is far more numerous than was formerly believed. This is not considered as evidence that the species is increasing, but merely reflects more accurate and scientific methods of appraising populations.

In many African countries, the black rhinoceros is strictly protected by conservation agencies, and in several parks its future seems assured. Modern methods of immobilization with drugs and subsequent translocation of these large mammals is now an entirely feasible management procedure. The value of the animal stems largely from its great tourist attraction, possibly because of its relative

rarity and reputed pugnacity.

As mentioned earlier, Tsavo probably contains the largest population of black rhinoceros left in existence, and it is essential to determine if the species will survive in the changing environment. The current study suggests that at the present time the population is stable and relatively large. Recruitment of young animals to the population appears normal. Their future survival in the park will probably depend mainly on how the habitat change progresses and in what direction.

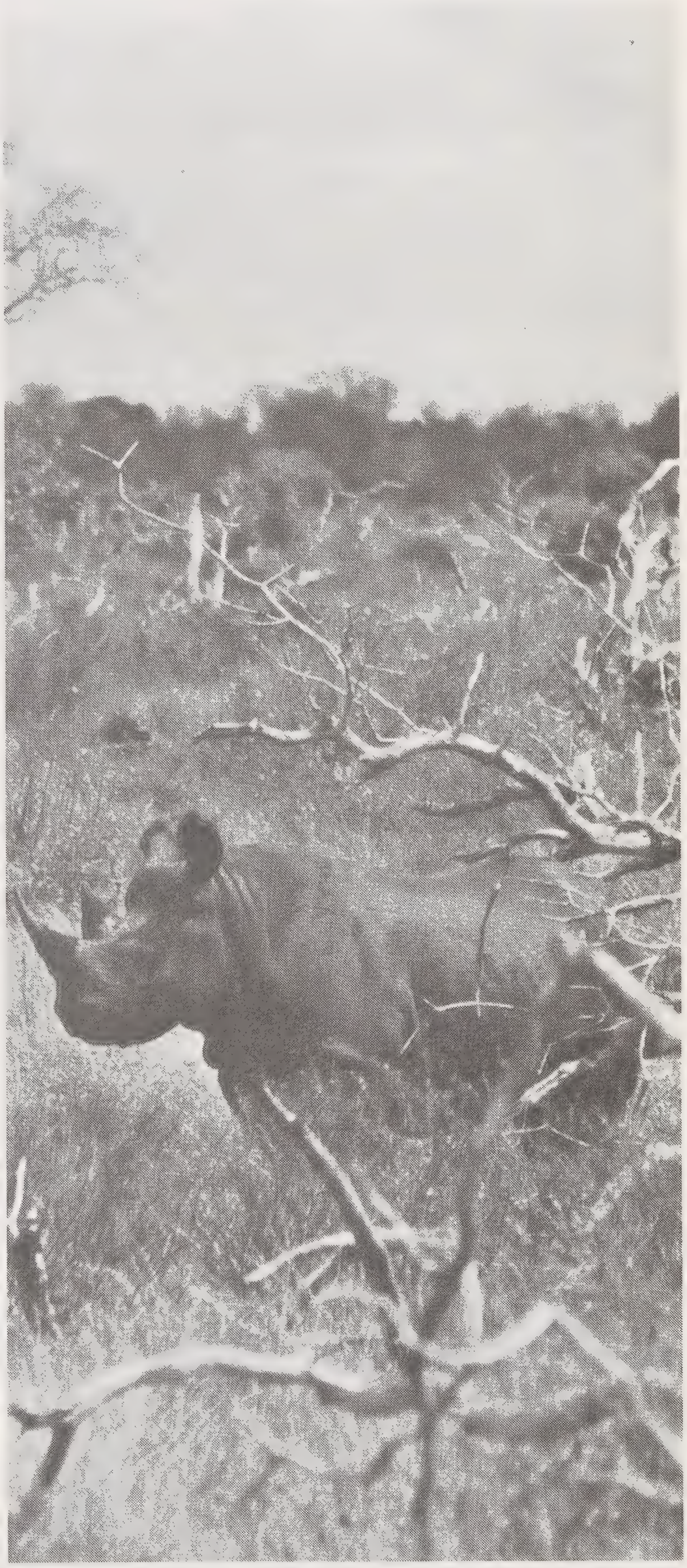
Recent ecological studies of elephant populations in East Africa have shown that in several areas these populations are declining. It has been suggested that these declines are related to habitat modification, taking the form of large scale destruction of woodland by over-populations of elephants. These changes are induced by the elephants themselves and are aggravated by fire; in general the combined effect is to convert woodland to grassland.

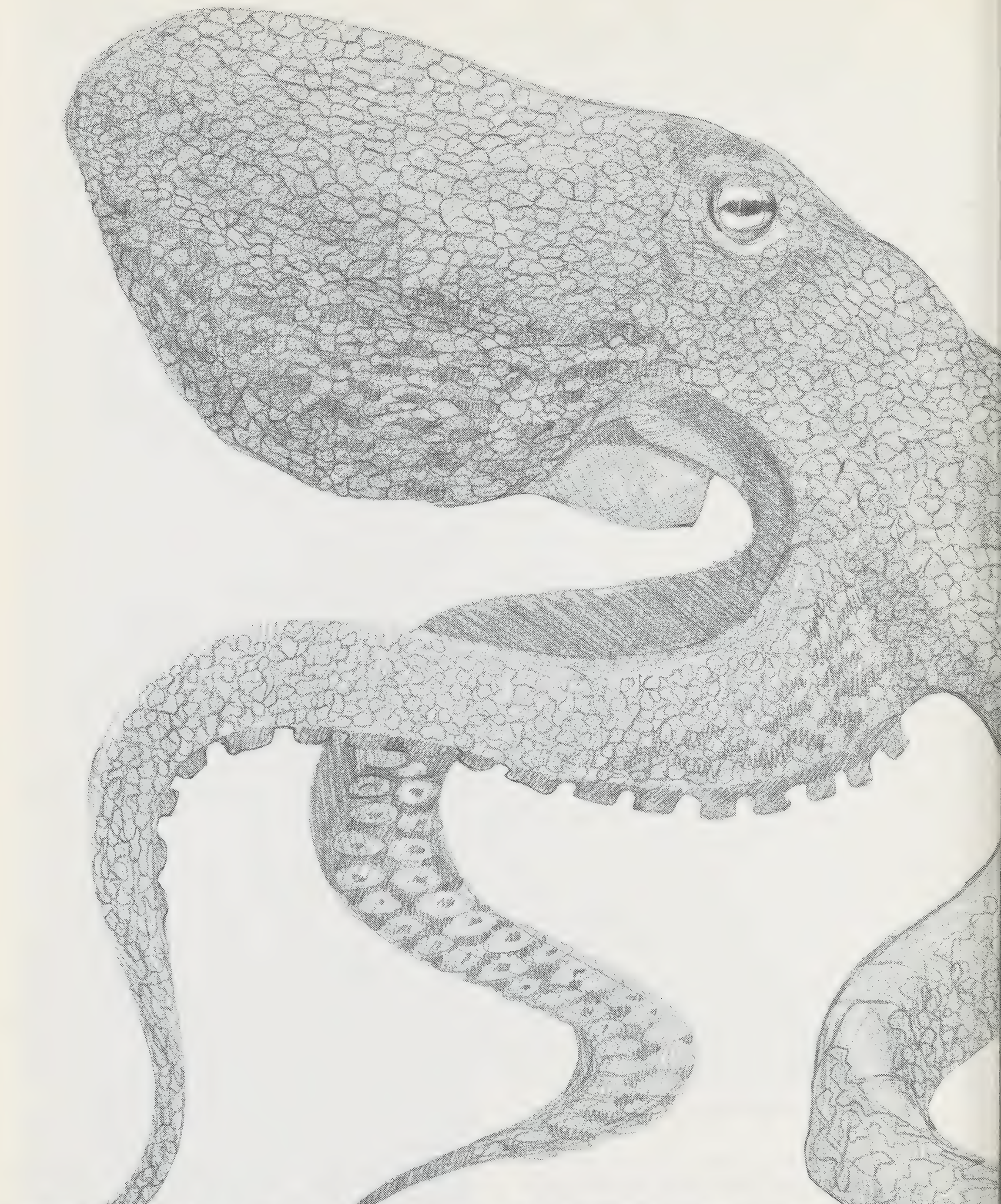
Several food habit studies conducted in East Africa show that a large proportion of the diet of the elephant is grass. However, recent research into elephant ecology suggests that healthy populations of elephants can only be supported in areas with extensive browse; moreover some scientists believe that the observed declines are related to the destruction of woodland, leading to a dependence on a diet made up almost exclusively of grass.

Browse is apparently an important requirement of elephants during dry periods. In Tsavo, heavy feeding and large scale destruction of woodland is very marked during periods of drought, as more browse is consumed by the elephants when the grasses reach the quality of a poor standing hay or wither completely. Over a series of droughts this could lead to severe food competition, to the detriment of the rhinoceros, and may ultimately lead to a reduction in the carrying capacity of the park for the species. The situation is aggravated by the low rainfall and by the fact that the elephants tend to concentrate along the permanent rivers during periods of drought; these are the areas where the high densities of rhinoceros are still located.

The current habitat change has not been entirely detrimental. With the environment developing toward grassland, the population of "plains game" has increased markedly. Species such as zebra, buffalo, and oryx have noticeably increased; this increase in prey species will probably result in an increase in the predators which prey on them, providing a greater variety of fauna. However, in the absence of emigration of the elephants, it will probably be necessary to reduce their numbers in order to stabilize the ecosystem. Research has indicated that there are several separate elephant populations in Tsavo, and at least one is probably in the preliminary phase of a decline. As a safety precaution, and however regretable, it will probably have to be the task of man to hasten artificially the decline through reduction of the herds, and thus stabilize the environment and encourage early regeneration of the woodland.

This young male rhino stands in an area which was formerly thick woodland. The change in habitat is one of the factors involved in the study of the black rhinos of Tsavo.





OCTOPUS

by U. Erich Friese

Through much of man's sea-going history, the octopus has been maligned as a destroyer of sailors and ships. a terror that drew man and vessel to untimely, wet graves. Few creatures have inspired such gruesome and colorful stories as this many-armed sea beast.

The legends of the ancient Greeks were among the first to dwell on such horror tales. When Homer (about 700 B.C.) described Odysseus' confrontation with Scylla – the inhabitant of the sea cavern – as "... being a terrifying sight, surrounded by a dozen feet she is always waving . . .," he was most certainly referring to a large octopus. Reports of similar encounters have continued to circulate throughout the centuries. Many of these encounters undoubtedly were provoked by insignificant incidents with octopus specimens captured unintentionally by fishermen. Such events were then eventually over-dramatized by the vivid imagination of early seafarers. But the oldtimers certainly had no monopoly on such make-believe. Modern film makers have done their share to slander the octopus – and so have a number of adventure writers.

Actually, the octopus is a distant relative of the inoffensive clam – it's a mollusc. More precisely, octopuses and the closely-related species of squid, cuttlefish, and the chambered nautilus belong to a group of animals known as cephalopods (from the Greek words *kephale* = head and *podos* = foot, meaning "head-footed"), which is ultimately placed in the phylum *Mollusca.* This phylum includes snails, mussels, clams, and oysters. They are all soft-bodied animals that usually secrete protective external shells. The ventral portion of the body is elaborated as a muscular organ, called the "foot," and used in locomotion. There are five classes of molluscs, including the cephalopods. In these the foot forms arms and tentacles surrounding the mouth, and a shell is either absent or greatly reduced. All cephalopods are essentially "blue-blooded" animals – their blood contains a copper compound, which gives it a very characteristic bluish coloration.

From available fossil records, it is estimated that at one time there must have been more than 10,000 species of cephalopods on this earth. Modern taxonomic zoology recognizes only about 650 valid living species. Octopuses are the best known of all the cephalopods.

There are about 150 different species of octopuses, which, like all other cephalopods, live exclusively in the sea. They are distributed throughout the world's oceans from the tropics to the Arctic and the Antarctic, and they vary in size from small, two-inch tropical species to the giant North Pacific octopus, *Octopus dofleini dofleini.* Reasonably authentic reports indicate the latter species may obtain an arm spread of over 30 feet and weights of more than 300 pounds. Usually, however, specimens in excess of 80 pounds will draw lots of attention and even make considerable headlines in the news media, especially when the animal is on display at a public aquarium.

In order to find out what makes an octopus such an unique animal, we have to take a closer look at its basic anatomical features. The globular body is covered by a thick muscular mantle, which encloses and protects the internal organs. The body narrows somewhat at the junction of the head, indicating a rather short neck. The front of the foot is completely disassociated from the rest of the body. It is intimately fused with the head, forming a complete ring of eight tapered arms. The posterior part of the foot is fused into a tubular funnel, attached at the lower side of the head. For sudden, rapid escape movements this funnel acts like a jet propulsion system. When the mantle cavity enlarges, the funnel valve closes and water is drawn inside. Once filled, the opening of the mantle cavity is closed off by muscular contraction and the water is forced out through the funnel under considerable pressure, propelling the animal rapidly away from danger. For its normal activities, however, the octopus crawls along the bottom with independent movements of its eight arms.

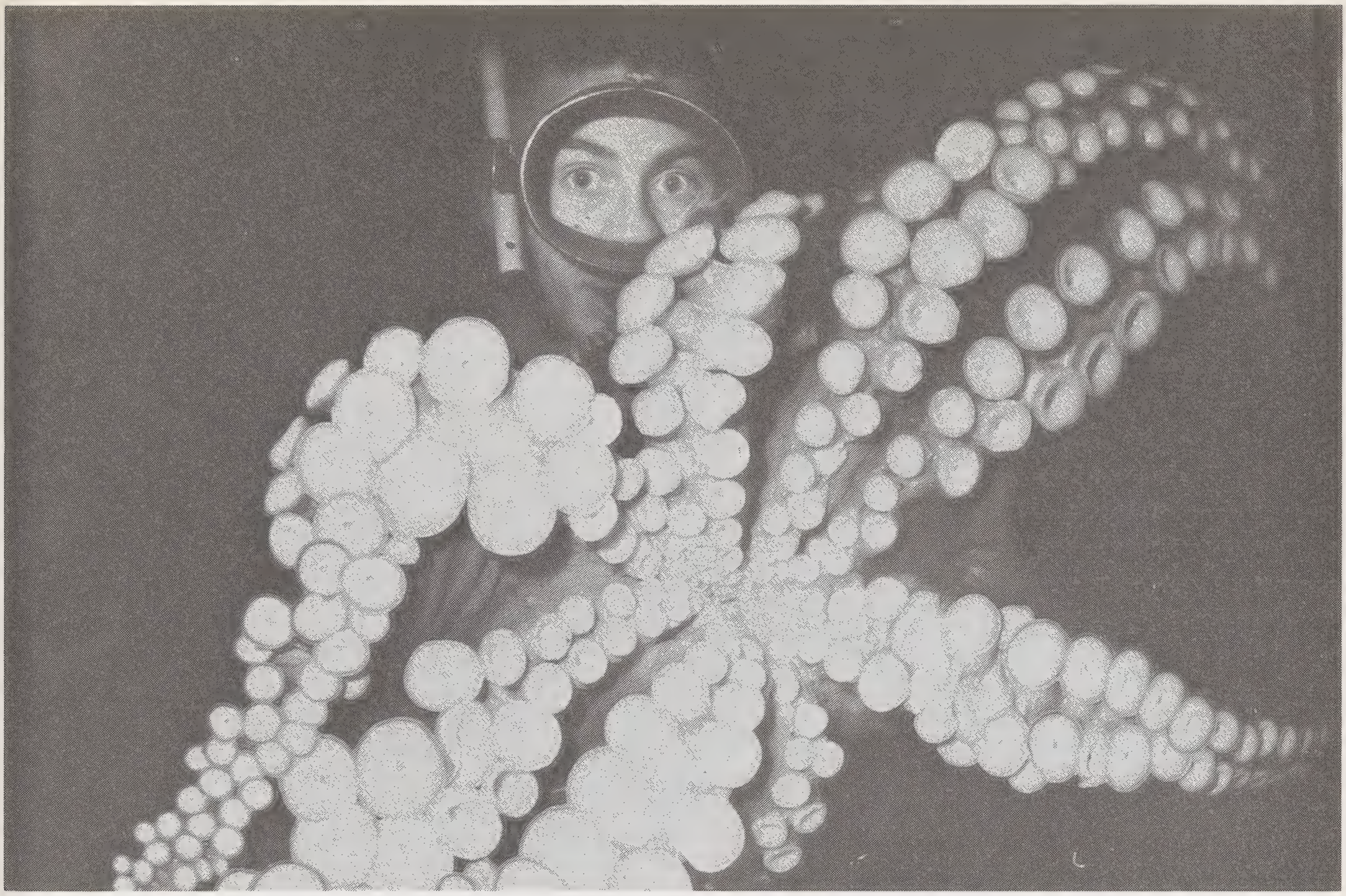
A spectacular feature of the octopus is its ability to change color very dramatically and in a very short period of time. Just beneath the skin – which is often covered with many wart-like bumps and projections – are many chromatophores, cells packed with black, yellow, or red color pigments. When the individual color cell is contracted, it is barely visible to the naked eye. By means of muscle fibers attached to it, the cell can be stretched out considerably. When fully expanded, the chromatophores will cover the entire body surface, thus permitting drastic color changes in a split second. In fact, the various colors seem to pass over the body in regular, well-defined waves, which range from a mottled bluish-grey to dark red and almost black. This incredibly efficient system enables the octopus to blend perfectly into almost any background, and as such acts as a superb camouflage mechanism.

The arms of the octopus are covered along their oral surface (the side pointing inward and toward

the mouth) with hundreds of sucking discs, which may measure up to two-and-a-half inches in diameter in the large North Pacific octopus. It has been established that a five-foot octopus can have as many as 2000 such sucking discs, which – in theory – may create a suction of up to a quarter ton. Although such force would tear the animal first before it would release the suction and remove the many discs from their attachment, it certainly demonstrates the ability of the octopus to hang on to almost anything. More than once has this author tried in vain to remove a small octopus from the glass wall of an aquarium.

Despite its awkward proportions, the octopus' motions are lithe and fluid, and the animal appears to literally glide along the bottom when out in the open. In its natural habitat, however, it is of a very retiring – almost timid – nature; it is a nocturnal animal which stays in its cave, crevice, or other hiding place during the day, and usually comes out only during the hours of darkness to stalk prey and feed. The primary food of the octopus consists of crabs, shrimp, and occasionally a slow-swimming fish. It catches its prey by seizing it with its arms or by covering it suddenly with the membranous web at the base of the arms. The final kill is made with the beak, a dark chintinous structure (very similar in appearance to a large parrot's beak) at the center of the mouth. A very potent poison may also be injected by the beak.

Largest of the 150 octopus species is the giant Pacific octopus (below). A record specimen from Puget Sound weighed more than 85 pounds at the Seattle Marine Aquarium (above).



A skindiver demonstrates the eight tapered arms of an octopus, with the hundreds of sucking discs pointing inward and toward the mouth.

The potency varies greatly, depending upon the octopus species. Some species may inflict only a puncture wound or cause some minor swelling in humans bitten while handling an octopus. Other species, usually the tropical ones, are known to have near-lethal effects upon humans, and some fatalities have been reported. The beak is retracted when the animal is not feeding.

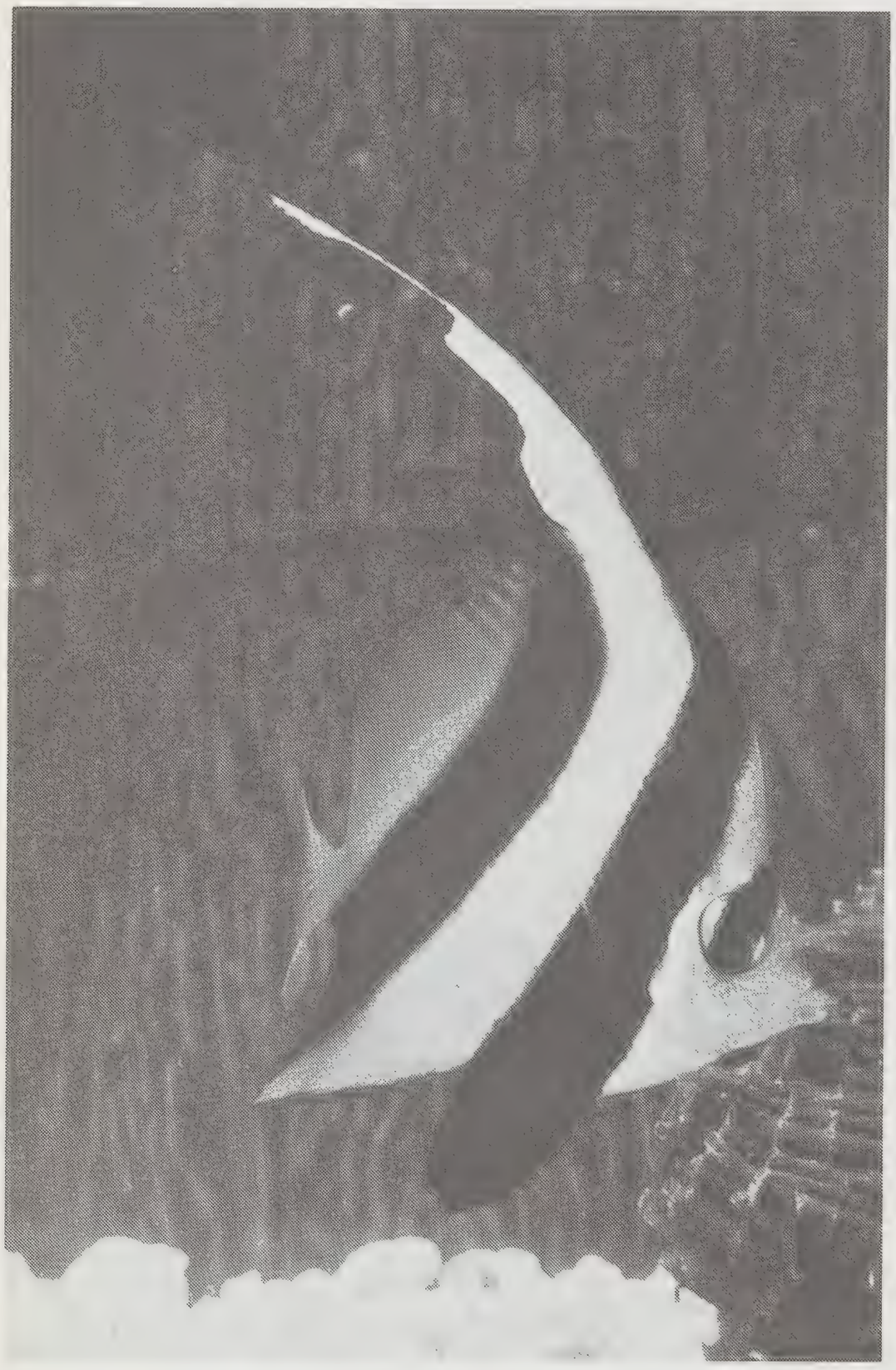
Among the worst enemies of the octopus are the moray eels in the tropical and sub-tropical waters and a variety of other large carnivorous fish in the colder waters. The ling cod, *Ophiodon elongatus,* in the northeastern Pacific is the arch enemy of *Octopus dolfleini dolfleini.* Although easily outmaneuvered by most attacking fish, the octopus has one additional weapon. If the animal is in acute danger or even alarmed, an ink sac, located at the posterior end of the mantle cavity, expels a dense cloud of an ink-like substance into the water. The defensive action of this ink has been much debated. It is commonly thought of as a smoke screen, but apparently it also functions as a momentary distraction, and it also possibly inhibits the sense of smell in some predators, thus giving the octopus sufficient time to escape.

There are no substantiated reports that an octopus, despite its fearsome reputation, has ever attacked a swimmer. Of course, with the innovation of self-contained diving units and the subsequently developing popularity of scuba diving, a new picture emerges. Divers will often provoke an octopus which is minding its own business. Thus, once sufficiently aroused, the animal will retaliate in kind. Usually, it will "attach" itself to the diver. An acute danger arises if some of the suction discs become fastened to the smooth surface of the diver's face mask. An inexperienced person will intuitively attempt to pull the octopus' arm off and consequently dislodge his face mask, which then will immediately fill with water. With his underwater vision eliminated, the diver will panic and subsequent disaster is almost inevitable. The experienced diver, however, leaves the octopus completely alone once it has attached itself to him, and within minutes the frightened animal will release its arms and beat a hasty retreat. Like so many other potentially dangerous animals, the octopus will always attempt to avoid an encounter with its enemy, but it will fight if its path to safety has been cut off.

In the final analysis, we have in the octopus a basically shy, very retiring animal, which has no inclination whatsoever to devour man. While established facts disprove the octopus' role as a sea terror, the imagination of man has created a monster of this mollusc.

AQUA-SCENES

Photographs by William Meng



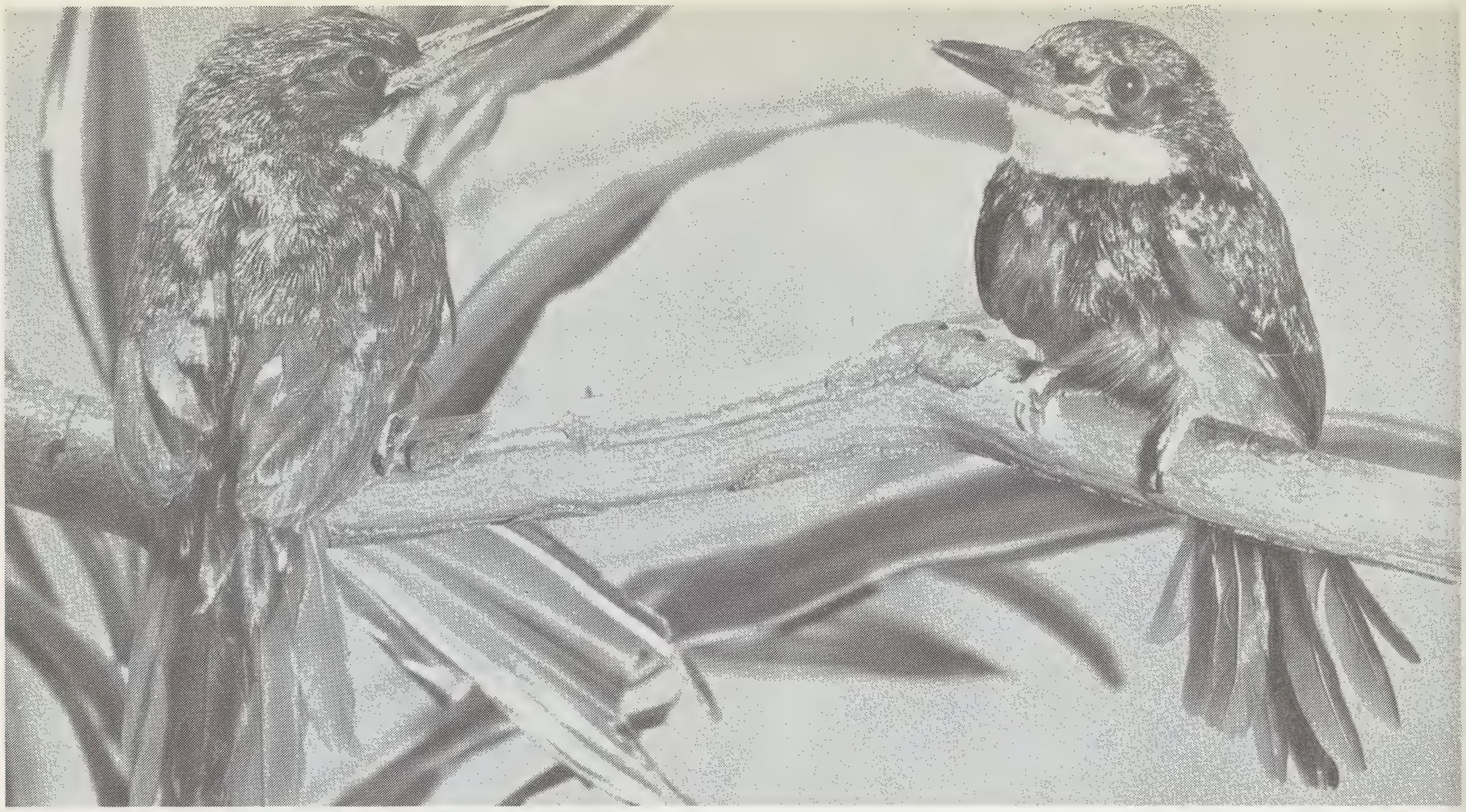
OVERLEAF: CREVALLE JACK
ABOVE: ARAWANA
AT LEFT: COACHMAN
BELOW: SMALLTOOTHED SAWFISH
OPPOSITE: SPINEY LOBSTER
PAGE 20: YELLOWHEAD JAWFISH

JACAMARS

Insect-eaters of the American Tropics by Alexander F. Skutch

Imagine a bird the size of a catbird, with a hummingbird's metallic glitter, daintiness, and vitality. Such a bird is the rufous-tailed jacamar (*Galbula ruficauda),* the most widespread and common of the 15 species of the Galbulidae, a family of birds allied to the woodpeckers, toucans, barbets, and puffbirds. It ranges from southern Brazil to southern Mexico, and is the only jacamar found north of Costa Rica. Most of the other members of this family confined to continental tropical America live in the Amazon basin and neighboring regions.

The resemblance of the rufous-tailed jacamar to an overgrown hummingbird is reflected in several of its popular names. Indeed, Brazilians use the same designation, *beija-flor,* for both hummingbirds and jacamars; and in Venezuela it is called *tucuso de montana,* or "forest hummingbird."



The rufous-tailed jacamar, a bird with iridescent plumage of glittering metallic colors, is rarely still or silent for very long. It seems to live in a state of perpetual excitement.

I still recall the difficulty I had writing a description of the first jacamar I ever saw, in the dim light beneath a grove of noble palm trees beside the Ulua River in Honduras, on a cloudy afternoon many years ago. Its plumage was so marvellously iridescent that I could not decide whether the predominant color was blue or green. Later, when I encountered a male jacamar in the open, it was clear that the upper plumage, including the central feathers of the bird's long tail and a broad band across its chest, were shining metallic green, with glints of gold and copper and bronze, as in hummingbirds. Its throat was pure white, and behind the broad green breast-band, the underparts were rufous-tawny or cinnamon, which was also the color of the outer tail feathers. The female differs chiefly in having a buffy instead of a pure white throat and a slightly paler abdomen. The long, sharp black bill is often held uptilted. The legs are short, and the feet have two toes directed forward and two backward, as in woodpeckers.

Rufous-tailed jacamars are rarely still or silent for very long. Like hummingbirds, they catch flying insects with a beak that appears too long and slender for such work; a flycatcher's broad bill would seem to be more effective for the job. But while hummingbirds concentrate on scarcely visible volitant midges, jacamars pursue some of the largest and most spectacular insects, including the blue morphos and other brilliant butterflies, dragonflies, and glittering beetles, as well as many smaller and more obscure flying creatures.

From an exposed lookout perch, usually at no great height, they make dashing sorties after passing insects, often twisting and turning with admirable skill. A jacamar seizes its victim in the tip of its bill, then carries the prey back to its perch. If the prey is large, it is beaten against the perch often until its wings become detached and flutter downward, before the bird swallows it. Jacamars seem never to eat fruit.

Few birds not classified among the songbirds sing so much and so pleasingly as rufous-tailed jacamars. Their high-pitched, rapid utterances combine with their appearance and actions to create the impression of a bird that lives much of the time at the highest level of excitement. The usual call is a sharp note – a squeak, a squeal, or a whistle. Similar notes are delivered with accelerated tempo and rising pitch to form an ascending trill. Often the trill is beautifully clear and soft. To hear two male jacamars competing songfully for a mate is a memorable experience.

Contemplating the jacamar's long, slender bill, one would expect to find it weaving a delicate fabric, perhaps a pensile pouch such as oropendolas and certain orioles make for their eggs. But this surprising bird does nothing of the sort; it digs itself a burrow in the hard earth or in an even harder termites' house. In Central America, I have found rufous-breasted jacamars nesting only in the ground, but in Venezuela I discovered two nests in

large, terrestrial termitaries, and in the same locality, one in a low stream bank. Jacamars will sometimes settle for a trailside bank only a foot high, or even a moderately steep, wooded hillside. Sometimes they dig their burrow in the vertical mass of clay heaved above the ground by the roots of a great, fallen tree.

The burrow is dug by the male and female working alternately. They loosen the earth with bills that seem too fine for such coarse work and kick the dirt behind them, just as kingfishers and motmots do. The work proceeds with much excited calling and trilling, and between spells of digging, the male may fortify his mate with a choice insect that he has caught. Completed tunnels in the earth range from about 12 to 20 inches in length, and at the inner end they expand into a chamber where the young are raised. Two burrows in termitaries that I examined were likewise horizontal, and each was about a foot long.

The pure white eggs are laid on the unlined floor of the chamber. Three seems to be the usual number of eggs, but sets of two and four occur. The female incubates through the night, and by day the two sexes alternate on the eggs, usually sitting from one-and-a-half to two hours at a stretch. While incubating, they regurgitate the indigestible chitinous parts of the insects they have eaten, including glittering beetle shards. This material accumulates to form a bed beneath the eggs.

The eggs incubate for 19 to 23 days, according to my observations made at several nests. Although most birds of the woodpecker alliance, including woodpeckers, barbets, and puffbirds, hatch with no trace of down, jacamars emerge from the shell bearing long, white filaments that are especially abundant on the chin and throat. Contrasting with the nestlings' bald heads, the fringe of filaments gives the newly-hatched chicks an aspect of bearded senility. However, this down is not sufficiently dense to hide the nestlings' pink skin. Their eyes are tightly closed; and on their heels are callose pads, nearly smooth rather than papilose or spiked as in some other picarian nestlings. The pads support the weight of the young birds, protecting the heels from abrasion as the young jacamars shuffle around on the nursery's rough floor.

Even before their eyes open, the nestlings exercise their voices while waiting for their parents to bring food. Soon they are calling and trilling like their parents, but with weaker voices.

Such volubility seems most imprudent on the part of nestlings raised in an easily accessible burrow in woodland where enemies abound. Once, however, I watched a coatimundi pass apparently unaware within 10 feet of a burrow from which the songs of young jacamars were issuing.

The parents bring the young a variety of insects, which if large are beaten against a branch before being taken into the burrow, one at a time. Although no effort is made to cleanse the nest, the nestlings' expanding plumage remains clean and fresh. Some young jacamars leave at the age of 19 days, when they are already feathered and can fly, but in wet weather the nestling period may be prolonged to as much as 26 days.

In light woods in northern Venezuela, I found a pale-headed jacamar *(Brachygalba goeringi),* a species smaller and duller than the rufous-tailed jacamar. Its head and neck were pale grayish brown, and the rest of the upper plumage was dull black, faintly glossed with blue and purple. The breast was crossed by a broad band of chestnut, above which was a white triangle surrounded by dark brown. The lower abdomen was dull white. Its long, dark bill was even more delicately slender than that of the rufous-tailed jacamar.

I soon learned that this bird had a mate, and that the pair were feeding nestlings, already becoming feathered, in a burrow 31 inches long and evidently dug by the parents in a high clay bank. In contrast to the rufous-tailed jacamars, which forage chiefly in the woodland shade, these pale-headed jacamars hawked for insects from the treetops, darting out from a lofty, exposed perch at the roof of the woods. They were nourishing their four nestlings chiefly with dragonflies and butterflies. Of the latter, they preferred the stout-bodied skippers (Hesperiidae), easily recognized by their short wings and hooked antennae. The birds held the dragonflies conspicuously, always one at a time, in the tip of their long bills. These jacamars ignored the striped-winged, slender-bodied heliconian butterflies that swarmed in incredible abundance in a neighboring wooded dell and, as is well known, are distasteful to birds.

While attending their brood, these jacamars were loquacious, often calling "weet weet" in a high, thin voice. The sound reminded me of the call of a small flycatcher, such as the wood pewee. Sometimes the jacamars delivered a series of these notes, which became faster and higher in pitch until they merged into a sharp little trill. At times the nestlings called with a similar "weet."

While I sat on a steep slope watching the burrow of the pale-headed jacamars, a tayra, a large weasel of omnivorous habits, almost bumped

into me, then turned sharply and ran just above the burrow's mouth without seeming to notice it.

I had the good fortune to witness the departure of two of the four nestlings. The first rose from the burrow's mouth to a tree directly in front of me, where it was promptly joined by both parents, which burst into song. Their singing consisted of crescendos of tweets and twitters, running off into high, thin trills. While performing, they turned their bodies from side to side and twitched their tails rapidly up and down, as though beating time to their notes.

They seemed to be jubilantly celebrating the fledgling's graduation from the burrow to the treetops, and at intervals the young bird joined in with its weaker voice, also flagging its shorter tail. The emergence of another fledgling later in the morning was also greeted by song, but much less prolonged than that occasioned by the first one. The youngsters, which still bore tufts of natal down on their fresh plumage, flew well and soon vanished through the treetops.

A few days after the last of the nestlings left, I returned to make some measurements and notes on the burrow. When I pushed in a flexible vine to probe its length, two jacamars unexpectedly flew out. Peering in then with my flashlight, I detected two more white-throated juveniles gazing down the tunnel at me. It was then only 5:30 in the afternoon and the sun still shone; the young jacamars had retired early. I continued to watch until the two juveniles which had fled were led back to the burrow by the parents. Then the parents entered.

Until I left them seven weeks later, the two parents and four young birds continued to pass their nights in this burrow. Perhaps this explains why pale-headed jacamars, although smaller, dig deeper burrows than rufous-tailed jacamars, which do not use their nesting burrows as dormitories. Unfortunately, lacking additional records of pale-headed jacamar nests, I cannot be sure that all or most are as long and as well situated as the nest I observed.

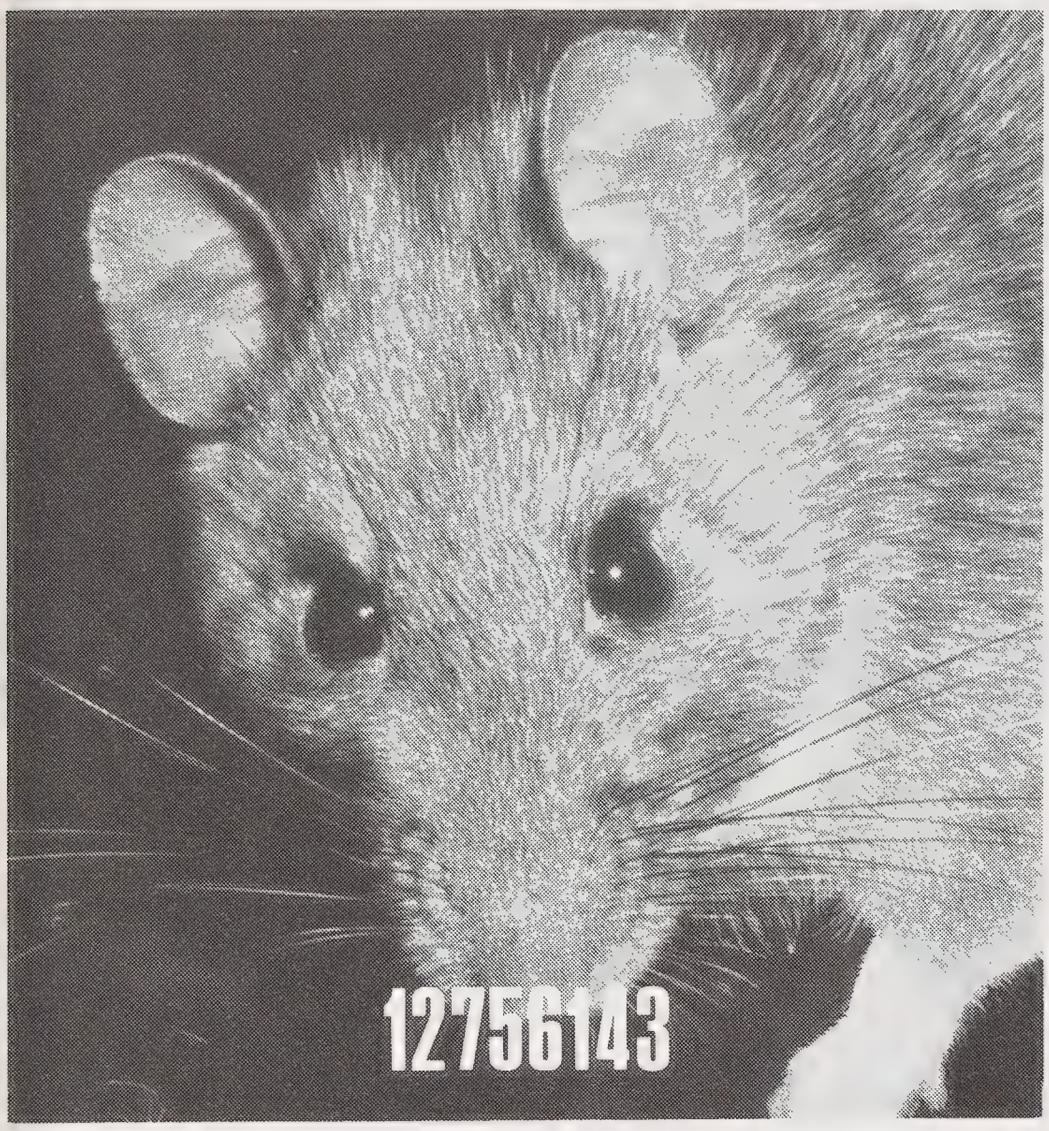
One morning last year, while wandering through a cacao plantation in the Caribbean lowlands of Costa Rica, I found the great jacamar *(Jacamerops aurea)*. It is one of the largest members of the family and, at least in Central America, a rare bird. A pair of great jacamars were perched high in a tree near the edge of a great tract of forest. Nearly a foot long, they were decidedly larger and heavier than their neighbors, the rufous-tailed jacamars, and their slightly down-curved bills were shorter and much stouter. Over their shining green upper plumage flickered glints of gold, copper, and blue. Below, they were largely rufous-tawny, except the throat, which was metallic green like the upper plumage. On the lower throat of the male was a patch of white that was lacking on his mate.

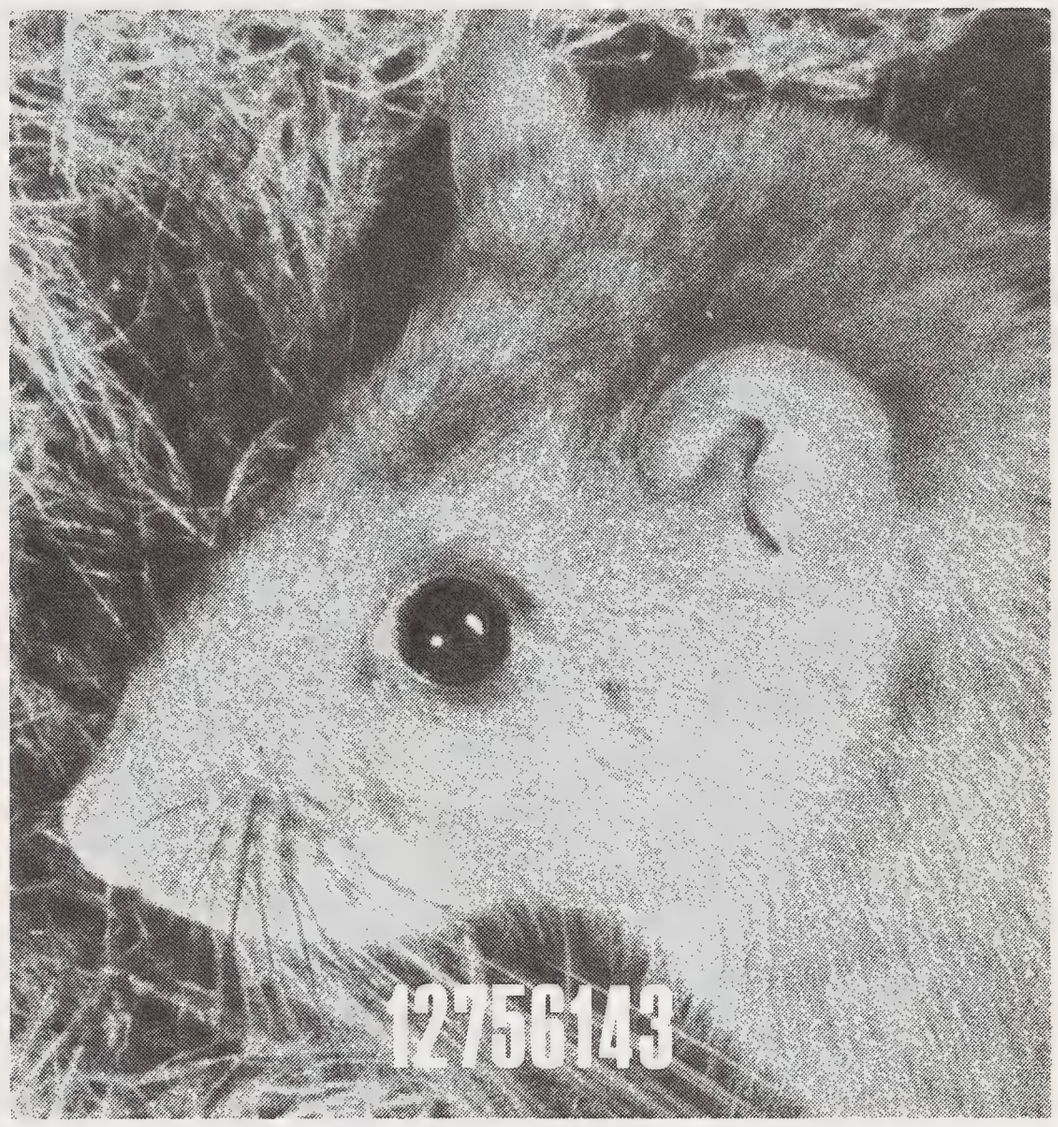
While I watched, delighted by the splendor of these birds, the male flew out, traced a long, tortuous course through the branches of the trees that shaded the cacao, and seized a large butterfly in his bill. He knocked his prey vigorously against his perch, but the four fluttering wings were still attached when he passed the insect to his mate. She continued to beat it against a branch until two wings fell off and drifted slowly earthward, then with difficulty she gulped the butterfly down along with the two remaining wings.

Presently the male jacamar flew to a small, roundish termitary 50 feet up the trunk of a tall tree. He stuck his foreparts into a small opening that the pair had evidently made in the side, then rejoined his mate on a neighboring branch. Soon the female went to the termites' nest and started to work. Her golden-green rump contrasted brilliantly with the black termitary to which she clung. With her head and shoulders inside the excavation, I could not see what she was doing, but tapping and crunching sounds revealed that she was enlarging the hole. She worked for a quarter of an hour, then her mate took a turn at carving into the structure. Thus, like the rufous-tailed jacamars, the two alternated at the task of preparing a chamber for their eggs; although the male did the smaller share of the work, he compensated by feeding his partner from time to time. Between spells of work, these jacamars caught insects on aerial sallies. In contrast to the volubility of rufous-tailed jacamars while digging a burrow, these big jacamars were rather silent. Once the male uttered a high, clear note as he alighted beside his partner with an insect, which she accepted with a grating or rasping sound. Other observer's have heard great jacamars deliver high-pitched whistles and nasal mews.

I was vastly disappointed when these splendid jacamars abandoned their work unfinished, apparently because their termitary had been built around some branches of an epiphytic cactus that obstructed their carving. As far as I know, nobody has ever seen the eggs of the great jacamar or followed its nesting. Indeed, as with a number of other families of tropical American birds, the details of the lives of jacamars are little known and remain for future naturalists to disclose.

UNDERWORLD CHARACTER





THE ALLEGHENY PACKRAT

BY JOSEPH A. DAVIS, JR.

From a look at the record he has all the earmarks of an unsavory personality – antisocial, a kleptomaniac, denizen of the underworld. But in person the Allegheny packrat is a throughly engaging beast. His underworld is literally that: the recesses in a cliff face, the tortuous interstices between the boulders in a talus slope, or the lightless grottos of a cave. In the first two habitats, a packrat above ground can be as furtive as any wild animal, but met in a cave he is totally without fear and every bit as curious about his human visitor as his visitor is about him. In all probability this fearlessness comes from the fact that the rat usually dens far beyond the "twilight zone," in the part of the cave where no light penetrates. In such a location, a straying predator could hunt only by playing blind man's buff, a game in which the rat, of necessity, has no peer. More of this later; for the moment an exercise in semantics is in order for the sake of the reader to whom "rat" is a word with loathsome associations.

There are no such things, zoologically speaking, as "rats"; that is to say, they are not classifiable into any taxonomic group to the exclusion of other animals. Species whose names include the suffix or surname "rat" are found scattered through no fewer than a dozen rodent families, along with other species commonly called mice, and many with names containing neither appellation. The name "rat" seems to be applicable, in the vernacular, to virtually any rodent larger than a house mouse and smaller than a rabbit. Most of these "rats" are inoffensive creatures, which have had the misfortune to resemble – sometimes poorly at that – the two species of rats which have intertwined their ecology with man's, the black rat and the Norway rat. These latter two are in many ways unique among the host of rats. It is their very uniqueness in habits and ecology that have made them anathema to man. And that anathema has been generously extended to all of the world's other "rats."

The Allegheny packrat *(Neotoma magister)* is found locally from the vicinity of West Point, New

A packrat investigating a new object, like this apple, aims its sensitive facial whiskers forward to get a tactile impression of it first. Normally it carries its whiskers fanned out to the sides.

York, south through the Appalachian chain to Tennessee, where it meets a northern race of the Florida packrat. Unlike the Florida packrat, whose choice of habitat ranges from swamps and woods to caves, the Allegheny packrat's life in inextricably bound to rocky places where deep fissures or caves occur.

My own interest in packrats was fired up 17 years ago on a bat-banding visit to a Florida cave, when I surprised the resident rat as he rummaged through my sleeping bag in a dry chamber near the cave mouth. His unhurried exit intrigued me, and in the course of subsequent visits, we grew very well acquainted. This behavior is a marked contrast with the packrat's antisocial attitude toward his own kind.

Following my return home to New Jersey, I had occasion to live-trap a number of packrats in two locations in the northern part of the state. In both places the rats lived in the deep galleries in the talus on the eastern faces of north-south ridges. They were extraordinarily local in occurrence, leaving piles of droppings under certain sheltering boulders but none a few feet away; I learned quickly that traps set away from these toilets rarely, if ever, caught a rat. However, at the latrines a trap would almost invariably imprison a rat on the first night the device was set out. Also, invariably, the rat would readily accept food from my fingers on my arrival, and from that time on, would be nearly as tame as if it had been raised in captivity.

One of the interesting offshoots of these trapping expeditions was the discovery that the packrats in one area in the Kittatinny Mountains regularly cut ferns and mountain ash leaves, which they deposited in sheltered places to cure into hay. The rats tended these stores, turning and rearranging the plants, presumably to assure that all cured properly.

Haymaking is a well-known habit of the pikas of the Rocky Mountains, but this was the first I knew of it in packrats.

But life is not quite idyllic for *Neotoma.* I once spotted a weasel poking around in the talus, and on another occasion caught two large pilot blacksnakes in the area. Both species are major predators of the rats.

Not much else can be said of the life of talus-living packrats, because the greater part of their lives is spent down in the inaccessible galleries between the rocks. But in a cave, a man can meet the packrat face to face and see the animal at its best.

Cavers who do not know the rat's habits have reported finding chambers in caves that housed colonies of "cave rats." But *Neotoma* is anything but colonial, and one rat will construct a number of nests in one cave room, giving the impression a colony exists. If the nests, which are made of shredded plant fiber for the most part, are in a room (either in a cave or building) whose temperature is influenced seasonally by the outdoor climate, the nests will have the form of a globe in winter. The entrance hole will be located in the side. As the room grows warmer in the spring, the

rat rebuilds the nest, moving the hole to the top, to allow its body heat to escape. If the cave becomes even warmer, the hole is enlarged, until the nest takes on the shape of a soupbowl. In really cold locations the packrat may add a few sticks to the nest to make it more massive and improve its insulating power.

In an environment devoid of light, the packrat uses its long facial whiskers as organs of touch and augments this with a remarkable kinesthetic memory — it knows every object and feature of its cave room, so that it can run to safety at full tilt should a predator appear. A predator, on the other hand, would find itself in a strange place filled with unseen obstacles and could only grope about while the rat skipped nimbly about in security. For this reason predators leave rats alone in caves and instead must lie in wait outside for the rat to make its nightly food-gathering forays. The "trusting"

The packrat's principal nest is usually located in an exposed part of a cave chamber, not far from an emergency hideaway in a crevice. Acorn husks and other trash often litter the immediate vicinity. The rat in these photos allowed her picture to be taken at close range; live-trapped because her cave was to be demolished, she gave birth in a cage the following day.

nature of the rat in its cave attests to this, and it is not unusual for a rat to sniff with interest at the boots of a caver who has just entered its chamber.

More than one neophyte spelunker has set his camera gear down in a cave to see a cave rat trot off with one of his flashbulbs. I remember arriving at one West Virginia cave with only a single small wire live trap, 18 inches long and 4 inches square. Locating a rat, I set about to bait my trap and place it on a rock ledge. The surface was uneven, which would cause the trap to wobble when the rat entered it. This might, I believed, frighten it off. So, steadying the trap with one hand, I searched the area around the trap for a small stone to place under it. I found one, but as I turned my attention to the trap, there was the packrat, halfway in the trap, reaching cautiously for the bait. He was a big one, and when the door dropped, it hit his rump. Most animals would leap at this stimulus, but the rat continued to gather the bait (all the while I was steadying the trap with my hand); then he backed out nonchalantly and went on his way. Had he been smaller I might have shoved him into the trap, but I was not sure he would have fit. I had a larger trap in my car, about a hundred yards down the slope, but I could not bring myself to reward such aplomb with capture.

The same sort of placid approach to humans and captivity was evident in a female I had caught in an old Pennsylvania mine scheduled to be blasted shut. This rat calmly took a five-hour ride in my noisy and hard-riding stationwagon, then gave birth that night in her new cage and reared her babies expertly.

Other packrats in caves have gently taken food from my fingers on only a few minutes acquaintance. But put two of these ingratiating creatures in one cage – or for that matter turn them loose together in a room 10 feet square – and a fight ensues. It begins with a sparring match, with both rats rearing up at whisker-length from each other. They strike out with forepaws like two Lilliputian

The plant fiber nests are subjected to continuing modification, and, sometimes, as here, are dismantled totally and moved to a new location.

This is a posed picture, but objects like this bandanna are commonly found near, or built into, packrat nests.

boxers. This is the sort of territorial fight that normally takes place in the wild, with much shrill squeeking, until one rat flees. In the confines of a cage, however large, the victor will press the attack to the other's death. In the wild, *Neotoma* loses its solitary inclinations long enough for mates to enjoy a brief courtship, and then the hostilities commence again. By rearing two littermates of opposite sex in the same cage, I found I could keep rats in pairs and breed them – sometimes for over a year. But each of these pairings ultimately resulted in a death, and after two or three such attempts I had to give up.

I have already mentioned the well-developed place memory of packrats in the wild. In captivity it was brought out in more detail. While studying at Cornell University some years ago, I had the use of a small room in which I could keep one rat at a time at liberty. I furnished the room with a variety of artificial rocks and hiding places. A rat would build a nest in each corner, but always preferred one of the four and built it more elaborately than the others. Elsewhere, under a box or hollow plaster "rock," the rat would make its hiding den, to which it retreated when disturbed.

If I chased it, the rat ran around the room in a predetermined path, running at full speed with its whiskers fanned out ahead of it. It would leap onto a low rock in its path, then dash onward. When I removed the rock, the rat leaped as usual, then seemed momentarily disoriented before continuing – obviously it had expected the rock to be there. If I placed the rock elsewhere in its path, the rat blundered into it, whiskers warning it just in time to soften the collision. This was in good illumination, so the rat was relying far more on its memory than on eyesight.

The Allegheny packrat, like its congeners, is not a prolific animal as rats go. Where the Norway rat may produce litters of a dozen, several times a year, the packrat has from two to four young at a time, once or twice a year. By a zoological rule of thumb, this suggests that the mortality rate of *Neotoma* is comparatively low, for in general packrats seem to be holding their own nicely, never very dense in population, but holding to the carrying capacity of the habitat. Except in areas where the dwellings of man are close enough to pose a threat of invasion by the Norway rat, the packrat seems to have a good chance of being around for a long time. Its occasional depredations among human homes are negligible and generally limited to the actions of a solitary animal. Petty theft is usually the indictment in these cases, and the charges will be examined in the second part of this article.

(Part Two will be published in a later issue.)

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

(Photograph by H. Miller)

A herpetologist at the Taronga Zoo, Sydney, Australia, displays one of the young Spencer's monitors hatched at the zoo, the first hatching of the species in captivity.

Taronga Zoo Hatches Spencer's Monitors

(The following report of the first hatching of Spencer's monitors in captivity was sent to ANIMAL KINGDOM by Uwe Peters, herpetologist at the Taronga Zoo.)

Sydney, Australia – In October 1968, Taronga Zoo received a pair of adult Spencer's monitors *(Varanus spenceri),* which had been collected while mating in the Tennant Creek area of North Australia.

The female subsequently laid 18 eggs, averaging 52 mm by 36 mm in size, on November 11. The eggs were not buried, but were scattered all over the peatmoss-covered floor of the terrarium. Four of the eggs were malformed and, after examination, proved to be infertile. The remaining 14 eggs were artificially incubated in five containers kept in a dark terrarium at a constant temperature of 85°F.

Four days after laying, one egg was lost through a fungal growth. On February 2, 1969, it was observed that two eggs were dehydrated to about two-thirds of their size. When opened for inspection, each egg contained a living embryo, one of 78 mm and the other 83 mm in length.

After an incubation period of four months and two days – unexpectedly short for a *Varanus* species – the first three baby Spencer's monitors cut the eggshell on March 3, 1969. At 7:30 A.M., half the head of the first came into sight, and the next morning, the fourth monitor cut its way through the shell. The same day, at 2:00 P.M., the first *Vananus spenceri* to be hatched in captivity completely emerged from the shell.

The total length of the first hatchling was 222 mm, of which the head comprised 22 mm and the tail 98 mm. The second lizard left the security of its shell at 3:30 P.M. Within seven days, all 11 monitors had hatched.

The young Spencer's monitors were more colorful than their parents. The neck showed two to three broad V-shaped yellow markings. The back was a velvet-brown, with eight to nine yellow bands, while the tail had four to six bands, which toward the tip broke up into irregular spots and stripes. The belly was a uniform white.

Six of the Spencer's monitors have been sent to other zoos in Europe and the U. S. A. At nine months, the average length of the five remaining at Taronga was 340 mm.

Dr. James A. Oliver Appointed Director of New York Aquarium

New York, N.Y. – Dr. James A. Oliver, zoologist and conservationist who has headed both the Bronx Zoo and the American Museum of Natural History, has been appointed director of the New York Aquarium. He succeeds Dr. Ross F. Nigrelli, a veteran of 35 years with the aquarium, who will continue in charge of the aquarium's Osborn Laboratories of Marine Sciences. Dr. Oliver's appointment is effective June 1.

During Dr. Oliver's ten years as director of the American Museum of Natural History – a post he assumed in 1959 – he supervised the activities of the museum's 13 scientific departments and the development of several major exhibit halls. He was especially concerned with research at the museum's Lerner Marine Laboratory in Bimini and was a consultant to the laboratory's shark research panel.

As a member of the Board of Directors of the Caribbean Conservation Corporation, Dr. Oliver, whose specialty is herpetology, has paid particular attention to the campaign to preserve the green sea turtle. This creature, which breeds in the Caribbean, has been greatly reduced in number.

Dr. Oliver has been active for several years in conservation activities and for the past year has served as the museum's coordinator of scientific and environmental programs. Early this year he was appointed environmental consultant to the New York City Administration of Parks, Recreation, and Cultural Affairs.

A native of Missouri, Dr. Oliver has been interested in animals since boyhood. He has collected reptiles and amphibians in many parts of the world.

One of his favorite animals is an Egyptian dabb lizard that he has kept in his various offices since 1952. Dr. Oliver says that the spiny-tailed, chunky creature, which the scientist acquired while at the zoo, now will accompany him to the aquarium. If the lizard lives for two more years, it will set a longevity record for its species in captivity.

"Dr. Oliver's experience with scientific and environmental programs could be hardly more appropriate to the aquarium, which is emerging as one of New York City's liveliest environmental education centers," said William G. Conway, general director of the zoological society. "Besides, we are delighted to welcome back his lizard to the society."

Notice for Members of the New York Zoological Society

Bronx, N. Y. – New York Zoological Society members are invited to view an entire new line of "members only" merchandise now available at the Bronx Zoo's Safari Shop. Dark blue silk ties with a gold society crest and the initials NYZS are now on sale for $7.50, upon presentation of a membership card.

Samples of other special items – pendants, charms, money clips, and tie tacks – are also on display. These items may be ordered at the shop, with delivery in approximately six weeks.

Also featured this year at the Safari Shop for all visitors are the British model animal miniatures, facsimiles of some 40 animals. In addition to educational toys and games with an animal theme, the shop also carries a selection of reasonably priced animal gifts. Of course, the proceeds of all purchases go toward fulfilling society objectives.

THE bookshelf

ED EMBERLEY'S DRAWING BOOK OF ANIMALS. *By Edward R. Emberley. Little, Brown and Company, Boston, 1970. $2.95.*

This book works. One evening I handed it to the two young (ages 5 and 6) bipeds that inhabit my house. Minutes later they returned, each with a sheaf of papers in hand. The papers were covered with drawings of pelicans, sharks, whales, lions, shaggy dogs, and the like. And the drawings were *good* using the tools that, with a touch of humor for both youngsters and adults, he has provided. They include the small dot, large dot, bird track, scratchy scribble, curly scribble, things, and shapes (the names are the author's). With these tools, youngsters can draw a "grumpy spider" or a "happy pollywog," a "croaking frog" or an "octopus looking up." This book successfully uses the youngster's natural liking for animals to teach the use of shapes in sketching. It's marvelous.

E.R.R.

THE NATURE OF ANIMALS. *By Lorus and Margery Milne. Illustrated by T. R. Funderburk. 255 pp. J. B. Lippincott Company, New York, 1969. $5.95.*

This book is really an introduction to zoology for the layman. It is well written and the illustrations are quite good. The authors have been successful in emphasizing the tremendous variety of animal life, from the smallest foraminiferan to some of the largest whales.

The discussion of sizes and shapes is very interesting and at the same time points out many zoological principles. The description of animal life by the habitat in which they are found is another good way of emphasizing the important ecological aspects of zoology. The field of genetics is covered in an easily understandable manner. A variety of animal adaptations are discussed. The distribution of animals and the past history of animals are dealt with in some detail. The last section of the book describes the relationships between man and animals and points out the very important need for conservation. Many crucial interactions, from the sharp rise in the human population to the rapid destruction of natural habitats and the control of pests, are discussed briefly.

The authors have covered the nature of animals and have presented even the most complex genetic and ecological principles in a very understandable and interesting way.

Donald Bruning

SNAKES: THE KEEPER AND THE KEPT. *By Carl Kauffeld. 248 pp., 39 photographs. Doubleday and Co., New York; 1969. $5.95.*

Carl Kauffeld has put together a highly readable collection of anecdotes growing out of his years of collecting and keeping snakes for the Staten Island Zoo. Anyone interested in these reptiles, or simply interested in finding and observing animals in the wild will enjoy this book.

The first few chapters deal with keeping snakes as pets, their housing, food, and behavioral requirements. The advice given is generally excellent, and couched in the midst of tales of snakes that have been kept by the author. However, in a very few instances the advice is misleading (e.g., captive snakes prefer dead prey, p. 7) or outdated (e.g., the discussion of mite control does not mention Vapona insect strips, p. 41).

Later chapters relate many interesting stories of collecting snakes in various parts of the United States. Each of these sets forth some of the joys and frustrations that belong especially to reptile collectors but also to nature photographers, field botanists and zoologists, and lovers of wilderness.

An unfortunate feature of the book are the verbal road maps that point the way to choice collecting sites. Localities mentioned in the author's earlier book, *Snakes and Snake Hunting,* were overrun and over-collected by snake hunters who followed his detailed directions. Although he is aware of the destruction to those snake populations, he nevertheless offers directions to new localities where several rare species can be found. Collectors in the southwestern United States have already taken advantage of the aid.

F. Wayne King

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Joseph A. Davis, Jr., is scientific assistant to the director, New York Zoological Park. **U. Erich Friese** is assistant curator of the New York Aquarium. **John Goddard**, a biologist, studied the black rhino in its home territory. **Alexander F. Skutch** is an ornithologist based in Central America.

ILLUSTRATION CREDITS

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DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

Puerto Rican Parrot

Amazona vittata

The Luquillo Mountains of Puerto Rico, which form a cloud-draped backdrop for the island's northeastern coast, were in the 16th century a last stronghold of the Carib Indians. Today, this rugged, forested mountain range is still a haven of sorts — not for fierce tribesmen but for Puerto Rico's only native parrot, which is practically extinct.

The Puerto Rican parrot, a green bird about a foot in length, is on just about everybody's list of endangered animals. Only a score or so of these birds may survive, according to Dr. Cameron B. Kepler, a United States Department of the Interior zoologist who is studying the Puerto Rican parrot.

In the Fall of 1968, when Dr. Kepler began his three-year stay in the Luquillo region, he searched the mountains for six weeks before sighting his first parrot.

Once this bird, one of the 13 native parrots of two genera *(Amazona* and *Aratinga)* now found in the West Indies, was common through most of Puerto Rico. By 1956, according to an estimate made then, only about 200 Puerto Rican parrots remained.

It would seem that the ecological deck has been heavily stacked against the survival of the Puerto Rican parrot. The parrot was hunted widely, and apparently was downed even by boys with slingshots. In addition, habitat destruction has shrunk the parrot's range to the island's mountain fastnesses. Introduced predators — the black rat and, it has been conjectured, the mongoose — prey on the parrot's eggs and young. More recently, the parrot has been threatened by a population explosion on the part of the pearly-eyed thrasher, an aggressive bird that is a competitor of the parrot for nest sites. Moreover, there is evidence that the 11-inch-long thrasher may prey on parrot eggs and young.

All this adds up to a gloomy outlook for the Puerto Rican parrot. If any factor is in the parrot's favor, however, it is that the bird's entire population seems confined to the Luquillo National Forest, 28,000 acres of tropical woodland administered by the United States Forest Service. The forest is at the same time a Commonwealth of Puerto Rico bird refuge. Therefore, unless the parrots stray from the forest into adjoining farmland, they are seemingly safe from interference by man.

The threat to the parrot from the pearly-eyed thrasher is another matter. Found in the scrub lands of several islands near Puerto Rico, and in the rain forests of Dominica, St. Lucia, and St. Vincent, the thrasher was relatively uncommon in Puerto Rico until the late 1940's. Now it has spread throughout the island and can be seen often in the rain forest of the Luquillo Mountains.

Unfortunately for the parrot, the pearly-eyed thrasher has unusual nesting habits for its family. Unlike its kin, this thrasher nests in holes in trees. So does the parrot, particularly in hollows formed when branches fall from the swamp cyrilla, or palo colordao tree. It is one of 240 trees native to the Luquillo National Forest and usually is found in valleys above 2,000 feet elevation.

Studies of the parrot's feeding habits have shown that it eats the fruits of more than 50 trees found in the Luquillo Forest. The diet varies seasonally, and from August to November depends largely on the tabonuco tree, which produces olive-like fruits.

The plight of the parrot has received increased attention in Puerto Rico during the last two or three years, a hopeful sign for a land whose populace has not been especially conservation conscious. However, it is possible that the parrot population has decreased to the point of no return, and that insufficient numbers of the Puerto Rican parrot remain to insure a viable breeding stock. Dr. Kepler's study may tell whether this is so.

EDWARD R. RICCIUTI

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ABOUT THE COVER

Front: Mule deer fawn *(Odocoileus hemionus).* This issue's cover photograph, which shows a mule deer fawn lying frozen in the undergrowth, offers a magnificent example of protective coloration. The photograph was taken by Donald Sanders, author of "Mimics, Tricksters, and Dazzlers" (see page 2), while on a geology field trip in Utah. In his article, Mr. Sanders writes of how color and pattern contribute to survival in the animal kingdom.

Back: Giant Pacific octopus *(Octopus dofleini)* guarding its eggs at the New York Aquarium.

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MIMICS, TRICKSTER

ANIMALS HAVE EVOLVED COLORATION AND PATTERN

,AND DAZZLERS

AT PROMOTE SURVIVAL

BY DONALD T. SANDERS

With startling suddenness the doe jumped from a thicket not 20 feet ahead of me and went bounding off to the left, up the mountainside. I had been hiking up Beaver Mountain in northern Utah, mapping the geology of the area. Now I stopped in my tracks, captivated by the sure-footed grace of the fleeing animal. After the doe – a mule deer – had disappeared around a shoulder of the mountain, I continued on my way, remarking at my luck at having seen so beautiful an animal at such close range. Before I had taken a dozen steps, however, I saw a tiny, tawny, white-spotted fawn next to a cluster of yellow flowers in the thicket from which the doe had darted moments before. Instinctively the baby deer stayed perfectly still, its mottled coat making it almost invisible against the sun-dappled forest floor. Indeed, I would not have noticed the fawn at all had my path led me a few feet to one side. Fortunately I had time to unlimber my camera and snap the picture that appears on the cover of this magazine before the frightened young animal, its fear overcoming its instinct to freeze, got uncertainly to its feet and fled in the direction that the doe had taken.

The near-invisibility of the fawn on Beaver Mountain was a particularly dramatic example of cryptic coloration, a kind of adaptive coloration that helps to protect animals from predators. Of the many kinds of cryptic coloration, natural camouflage is particularly common in young animals which are especially vulnerable to predators. Fawns lose their spots after a few months, when their safety no longer depends so exclusively on their ability to lie still and blend into their background. Although when a deer is mature its tawny coat helps it to remain inconspicuous, its chief defense is its agility and fleetness of foot.

Similarly, in the Arctic, the gray seal gives birth to white offspring, which are difficult for predators to see against the snow and ice of their environment. But in two or three weeks, when the young learn to swim, their fur becomes darker and matches the water in which the seals will spend most of their time.

Every animal has some defense against its natural enemies. Some defenses are structural, like the shell of a turtle; others are functional, like the

stinger of a worker bee. Adaptive coloration, or camouflage, is a more subtle defense, yet it is often more effective. Predators that hunt by sight can hardly prey upon what they do not see.

Many animals can change their coloration to conform with a changing background. The chameleon and related reptiles are well known for their ability to change their skin color, in seconds, through different shades of yellow, green, reddish-brown, and even blue. In northern North America the snowshoe hare, grayish-brown during the summer months, turns white when snow covers the ground in winter. Because of this seasonal variation, the animal is also known as the varying hare. However, experiments have shown that blindfolded hares do not change color. Hence, the color transformation must be triggered by physiological changes related to the animal's sensing that day length is decreasing.

Many fishes, as well as marine mammals like the whale and dolphin, are protected by a type of coloration called countershading. They are light colored on the bottom, grading to dark on top. Thus from above they blend with the darkness of the water beneath them, and from below they tend to be inconspicuous against the light filtering down from above. The flounder, a flatfish which glides along the sea floor in search of food,exhibits countershading with a refinement: its ventral surface remains white while its upper surface, normally dark, changes hue to blend with the color of the sea bottom. This adaptation acts both to help protect the flounder and to enhance its efficiency in capturing prey.

Natural selection, of course, plays a key role in the coloration of animals. In New Mexico, for example, where light desert sands are interspersed with areas covered by dark basalt from ancient lava flows, native rodents and lizards are predominantly light-colored if they live in the sandy areas, and predominantly dark if they make their home on the basalt. Near the boundary of basalt and sand, moreover, the numbers of light and dark individuals are about equal.

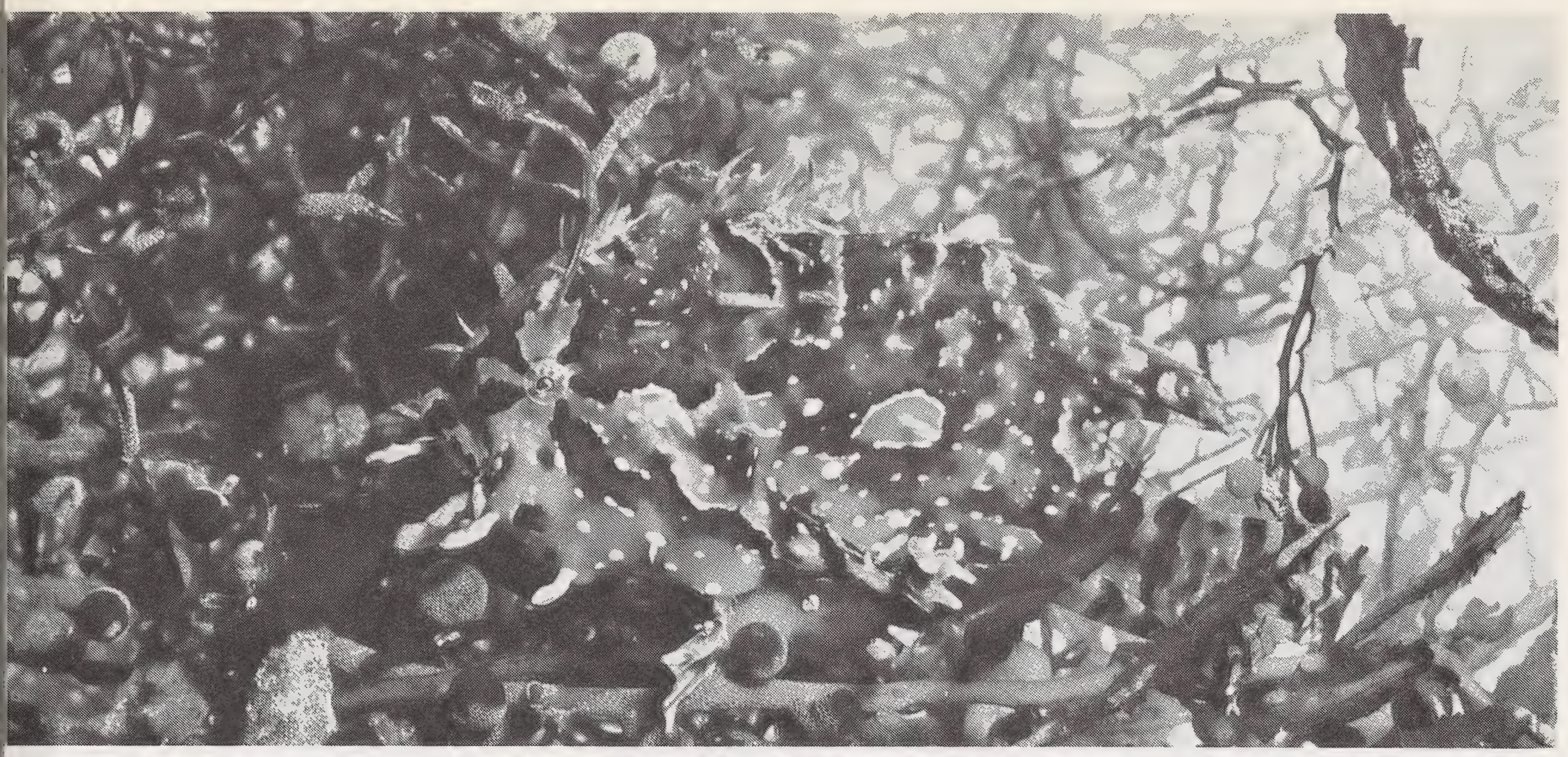
An interesting, if distressing, example of natural selection at work is the phenomenon known as industrial melanism. In the industrial Midlands of England, the bark of trees in the cities has been darkened by carbon particles from the polluted air. Moths that alight on the trees belong to species that are normally light-colored; but near the cities, darker individuals (those with more melanin) are safer – and in some areas they now make up 80 percent to 90 percent of the population. Naturalists estimate that within 80 years virtually all of the moths will be dark, because light-colored individuals will have become too conspicuous and therefore more vulnerable to predators.

Animal camouflage is in most cases a passive phenomenon: the animal simply remains still, and its coloration blends with the background. Some animals, however, take a more active role in camouflaging themselves. For example, the bittern, a wading bird that nests amid the brownish reeds in marshes, backs up against the reeds when it spots a predator and thrusts its narrow, graceful neck upward. Dark stripes along its neck and breast are then parallel to the reeds and blend with them. And should the reeds sway in the wind, the bittern sways too.

The coloration of some animals is designed not to blend with the background but, quite the contrary, to clash with it. The profusion of bright colors known as dazzleshading, evident in many species of birds and fish, especially in the tropics, fools the predator into looking at colors or patterns and not at the prospective prey. A similar effect is achieved by disruptive coloration, but instead of creating a pattern of its own, disruptive coloration serves to break up the animal's outline.

Many animals reveal bright colors while in motion, but hide them when coming to rest. Called flash displays, the colors create a diversionary effect in that the animal seems to disappear when it stops moving. Flash displays are common among birds and butterflies. The kallima butterfly of India, for example, has beautifully colored

An American bittern (overleaf), neck raised gracefully to match the lines of the swaying reeds, blends into its background. Now you see the sargassumfish (below), isolated from its natural environment. . .



. . . now you don't, as it clings to a clump of sargassum weed which it so closely resembles. So well adapted is this fish that it can slowly change color to match the color variations of its surroundings.

leaf-shaped wings – vivid orange and purple, or blue and purple – but only on the upper surface. The underside is a dull brown. Upon landing, the butterfly closes its wings so that only the underside shows – and the animal looks very much like a dead leaf.

The conspicuous coloration of some animals is designed less to confuse predators than to warn them away. The malodorous defensive weapon of the skunk is well known, and the skunk's easily seen black-and-white stripes remind potential enemies to be careful about attacking a second time. Most fossorial animals, which burrow in the ground or hide under rocks or logs, have little color; they apparently have no need for it. Yet the coral snake, which spends most of its time hidden under debris on the forest floor, is brightly marked with red, yellow, and black rings. Like the skunk's stripes, the coral snake's coloration may serve to warn predators away from the serpent's poisonous bite.

The scarlet king snake is a nonpoisonous species that closely resembles the coral snake. Lacking the latter's venom, the scarlet king snake relies on its similar coloration to keep predators at a safe distance. This kind of adaptive coloration is known as mimicry.

Butterflies and moths provide some of the best examples of mimicry in the animal world. The viceroy butterfly, for example, looks almost exactly like the monarch butterfly except that the monarch is larger. The pattern of orange and black coloration on the wings is virtually identical. The viceroy thus gains protection because predators, presumably, have learned that the monarch is a bitter-tasting victim. Similarly, one of the robber flies, through natural selection, has come to resemble a bumble bee with its yellow and black coloration. The resemblance helps protect the robber fly because most predators have learned not to eat bees.

Some animals mimic not only the color, but also the form of other animals – or even of plants or rocks. Thus the sea dragon, *Phyllopteryx,* closely resembles the sea horse, *Hippocampus,* which itself grows filaments that look like pieces of seaweed. And the sargassum fish, which lives amid the great beds of sargassum weed that float in warm Atlantic waters, has grotesque, leaf-shaped appendages that make it almost indistinguishable from the plants around it. Scorpion fishes and rockfishes have the coloration and even the irregular form of rocks lying on the bottom of the sea. The mimicry of these fishes serves to disguise them from unwary prey as much as to defend them from enemies.

It is defense, of course, that is the prime purpose of adaptive coloration. An animal's capacity for camouflaging itself – blending into its background for protection against predators – is one way of ensuring that it will survive and reproduce. The development of adaptive coloration, through the selection, generation after generation, of those individuals best fitted by camouflage against their natural enemies, is but one of many ways in which nature has been able to preserve species. The beauty that has resulted is but one of nature's bequests to man.

CONES

Beautiful But Dangerous Snails of the Sea

by Fay H. Wolfson

Beauty masking deadliness – a combination not uncommon in nature – always piques man's interest. Poets and moralists have celebrated the paradox of the thorn in the rose, but the flower's more spectacular and truly deadly zoological analogue, the marine snails of the genus *Conus* are relatively unknown. The thorn of the rose is visible, its prick annoying at best; the poison dart of the cone shell is always hidden, its sting often lethal. Even when a cone is in action, very little of the soft body can be seen and there is nothing to suggest or to warn of the perilous blow the animal can deal.

The many species of this genus of molluscs are found throughout the world, primarily in warmer waters. The topology of shell shape – two unequal cones attached at their bases – is remarkably consistent. Obvious differences between species of cone snails are the size, thickness, color, and pattern of the shell.

Long prized for the beauty of their shells, the poison cones have chalked up a record of 51 fully-authenticated stingings of humans – 15 of these incidents fatal. The ability of poison cones to inflict a mortal wound has been known since time immemorial to tropical islanders, who believed that the cones spit their venom. Practical recognition of the poisonous types is still part of the folklore handed down from generation to generation. The people of Yap in the Caroline Islands call the venomous species "th'm thow," meaning spit-swell. Children are instructed to pick the shells up by the big end and to hold them well to leeward so that the poison is not blown toward them by the wind or, in the water, so that the current carries it away from them.

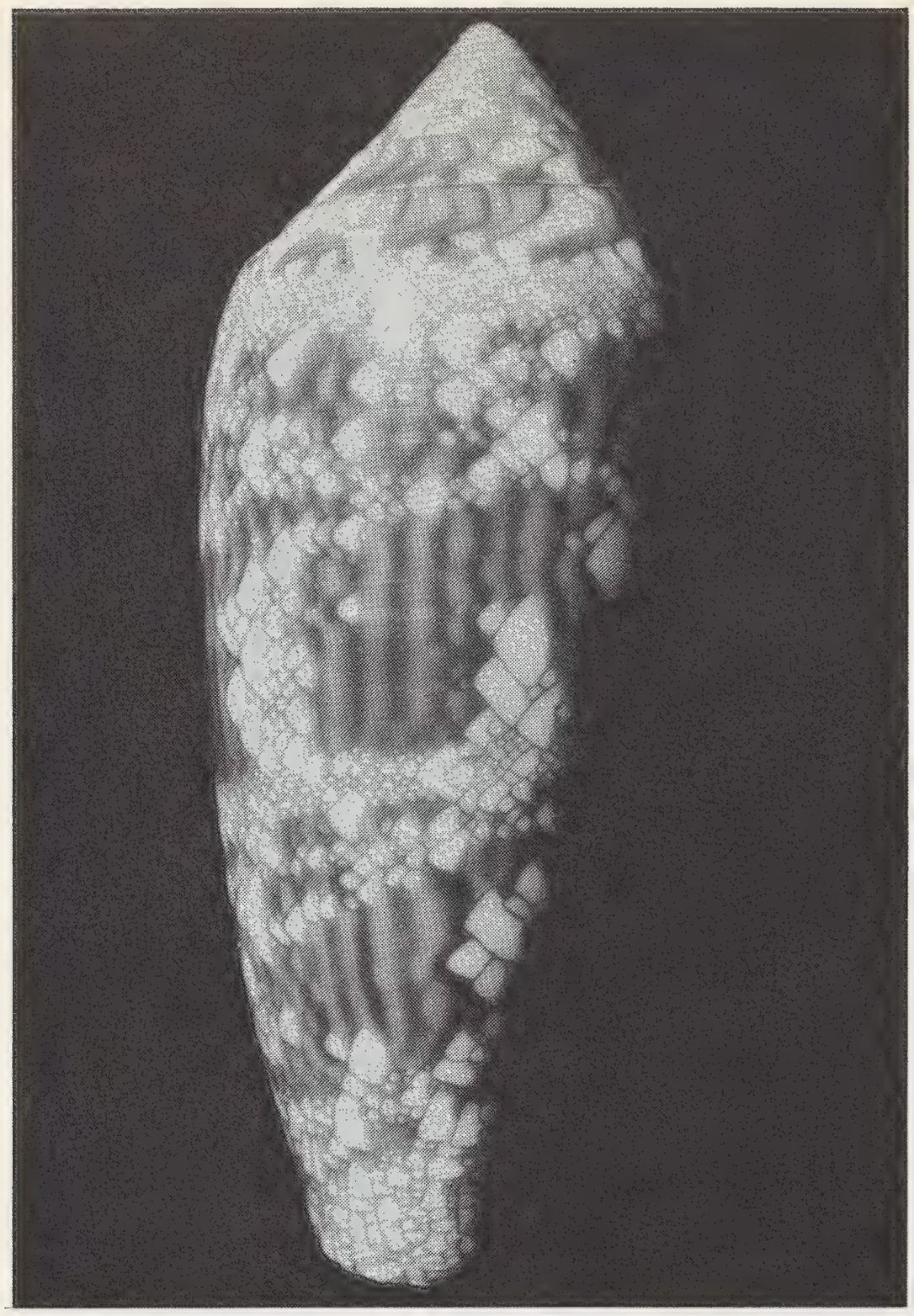
The first report to reach the Occident of the deadly capabilities of the cone group appeared in 1705, when the Dutch naturalist, G. E. Rumphius, described the death of a Banda slave. Stung while holding a cone, "... she felt a faint tickling sensation in her hand which crept slowly through her entire body – she died on the spot." Ninety years later, Arthur Adams, a British naval surgeon aboard the H.M.S. Samarang on a cruise to the Indonesian Archipelago, reported a stinging by *Conus aulicus.* He was the first to suspect that the injury resulted from venom injected by the radula tooth of the snail.

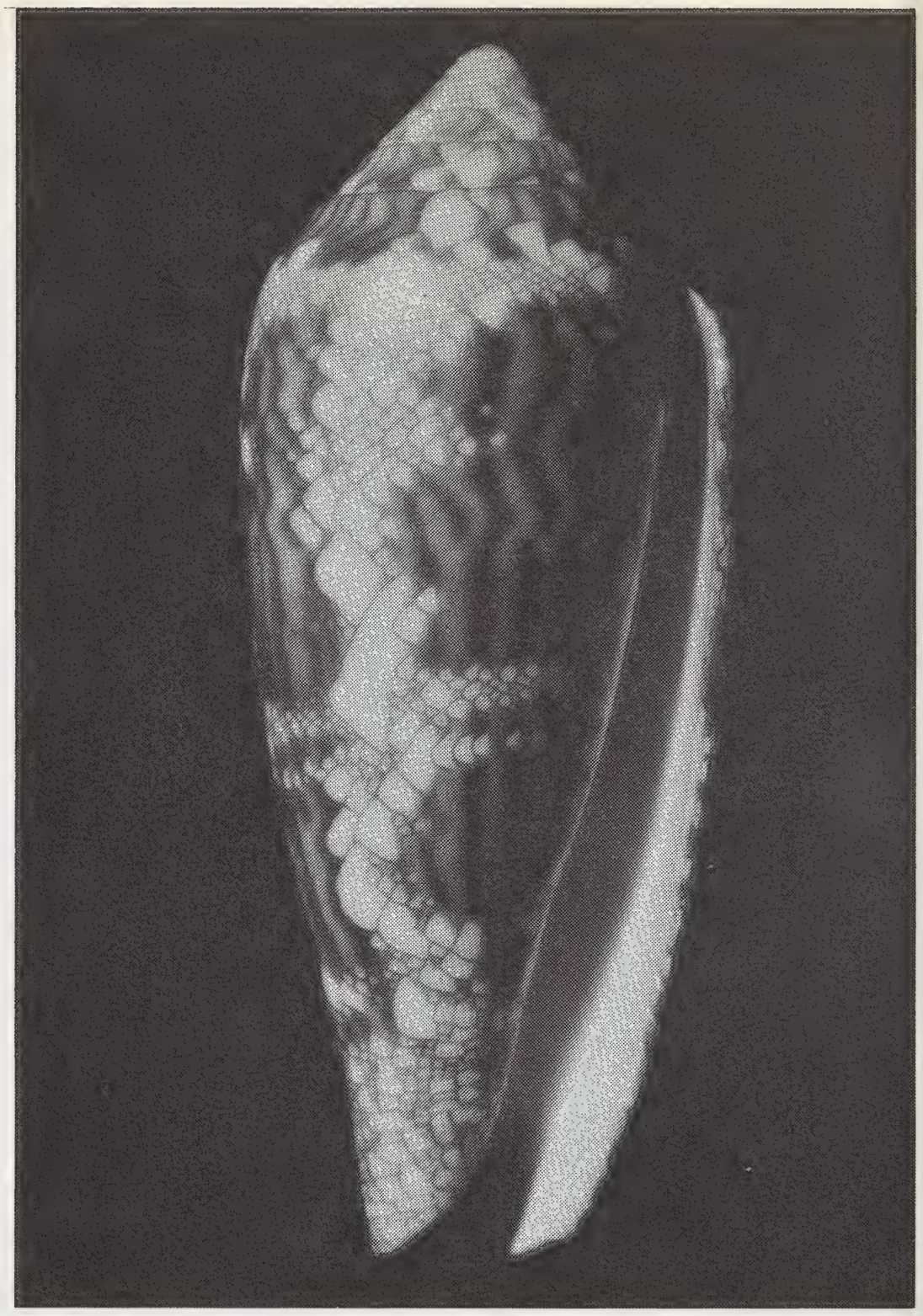
In the years that followed, further deductions as to the venomous nature of the cone shells were made from morphological and histological studies of preserved specimens. Then, during World War II, with the spread of United States servicemen through the Indo-Pacific, the United States Navy became concerned for the safety of its personnel in the strange waters of Oceania. The coral reefs, teeming with exotic and dangerous animals, were being explored by servicemen at work and play; the cone shells, irresistibly attractive and easily handled, were a predictable major threat. It was obvious that much more than the information then available was needed in order to alert the serviceman for his own protection. Research programs were initiated. Support for ecological studies of the cones was granted by the National Science Foundations; the U. S. Office of Naval Research underwrote investigation of the venom; the University of Queensland sponsored study of the toxicity of Australian species. At last the living animal became the object of attention.

Shells of the genus *Conus* are readily recognized by the shape their name suggests. Some 2,700 variants of the basic form have been distinguished and given species names. Eleven hundred of these are fossil. Another 500 are considered valid extant species; they differ sufficiently and with enough consistency from each other to be unequivocally accorded distinct identities by conchologists. The remaining 1,200 are subject to review by the specialists. As we begin to understand more of the degree of variability inherent in natural populations, and with increasing knowledge of the animal, its habits and ecology, many of these taxonomic questions will be resolved.

The genus is placed in the taxonomic suborder Toxoglossa, literally meaning "poison tongue." Its geographic distribution is, with a few exceptions, circumtropical; species of *Conus* are found in every tropical sea and are particularly characteristic of coral reefs. Although most abundant in shallow water, cones have been taken at depths as great as 400 meters.

The shells of cones come in a range of sizes: a mature *Conus pygmaeus,* for example, will be less than 25 millimeters long; the deadly *C. geographus* may measure 75 millimeters; *C. leopardus* reaches 200 millimeters and weighs several pounds. Luster and pattern are often all, or partly, hidden beneath a more or less shaggy coat, the periostracum. The shell may be dingy or bright, plain or complexly patterned. The more spectacular species show, within a narrow spectrum of color, a lavish diversity of design that boggles the mind. These elegant designs are often repeated in the living flesh, presenting a marvel of fluid beauty as the





Overleaf: *Conus marmoreus,* from Madang, New Guinea; above: two views of *Conus aurcus,* from the Philippines.

animal glides gracefully over the substrate.

The genetic stability of the genus through the long course of its evolution from the ancestral cone is reflected in intricate variations on a number of central themes which occur over and over in species that are widely separated geographically. For example, the "tent" pattern of *Conus dalli* from the Gulf of California resembles that of the South Pacific *C. textile,* a South African *C. lavendula* and a *C. purpurascens* from Central America look much alike, and the dot-and-dash pattern of a West Mexican *C. regularis* is very similar to that of a *C. spurius atlanticus* collected in Florida. Therefore, although shell pattern has served as a major distinguishing feature between species, even a specialist may have difficulties if he does not know the place of origin of a shell.

Various uses have been made of cone shells by natives of Oceania. On Tahiti and Pingalap atoll in the Ponape district of the eastern Caroline Islands, large cone shells, such as that of *Conus leopardus,* are used to peel the breadfruit. As the fruit is scraped with the edge of the shell, the rind falls through a notch cut in the outer lip – a primitive equivalent of our potato peeler.

On Yap and on Kusaie, some species of *Conus* are roasted in the shell. They are reported to be tough but of good flavor. Cones are harvested for food in the Gilbert Islands; women and children work the windward reef, while the men collect in the deeper waters of the lagoon. After boiling, the shells are broken and the meat withdrawn. The venomous nature of the animals is, apparently, not recognized; all species are referred to as "Te Nuou" or "Te Nui nuo." Okinawans, on the other hand, although aware of the deadly potential of the cones and familiar with the dangerous species, also utilize them for food. The solid meat is added to a stew featuring other molluscs, such as the turban shells, conches, and the cowries.

Very old rings, possibly ear ornaments, made from cone shells have been found on Polynesian-inhabited Kapingamaraingi atoll. On Yap, bracelets made from segments of large cones are called "yatau" and predated stone money as coin of the realm – to possess an adz, a pounder, and a "yatau" was to be a wealthy man.

The most famous mollusc of all time, *Conus gloriamaris,* the glory-of-the-seas cone, was the world's most sought-after shell for two centuries. Unquestionably handsome, it has been suggested that its surpassing beauty lies largely in the eyes of the covetous beholder. The first known specimen is listed in a Dutch catalogue dated 1757. In 1777, the shell was lent to Johann Chemnitz, a Danish clergyman and conchologist, who described it and

gave it its scientific name. That specimen is now in the Zoological Museum in Copenhagen.

By 1792, several of these glamorized cones were in private collections. One belonged to the Duke of Calonne, French Minister of Finance shortly before the Revolution. Danish-born Christian Hwass, art collector, amateur astronomer, and shell fancier, owned another. A persisting legend, apparently unquashable in spite of repeated evidence of its apochryphal nature, is at least illustrative of how avidity may affect otherwise rational persons. Based on the misunderstanding that the only specimens were the two owned by Hwass and the duke, the story goes that Hwass put his shell up for auction. After spirited bidding, the duke's offer prevailed. His rivals withdrew and he received his prize, only to crush it under his heel, exclaiming, "Now mine is the only one."

For a shell specimen to be completely acceptable to either scientist or *afficianado,* it must have been collected alive and it must be accompanied by reliable data in regard to date and place of collection. The reasons are twofold: even if undamaged, dead specimens lose luster and color, and only with the complete animal – shell and soft parts – is it possible to be certain that the species is native to the collection locality. Shells may be carried off by birds or eaten by fish which range far afield; dead shells may be transported long distances by ocean currents. Many a conchological "in" joke has resulted from the presence of species seas away from their home. Exotic shells found at Ballast Point in San Diego Bay got there in sand ballast taken on by ships in far-off ports.

The five specimens of *Conus gloriamaris* that had been collected by 1836 lacked data. With only

This shell of *Conus geographus* measures over 3 inches in length. The venom of this species is particularly deadly.

the vague designation of "western Pacific" as their place of origin, the feverish hope of finding more was largely frustrated. But in that year, Hugh Cuming, an ardent naturalist who has been called the Prince of Shell Collectors, undertook a voyage to the Philippines. Imagine his excitement when, on a coral reef on Bohol Island, he found two immature specimens under a stone. In a letter to a friend, he wrote, "I nearly fainted with delight."

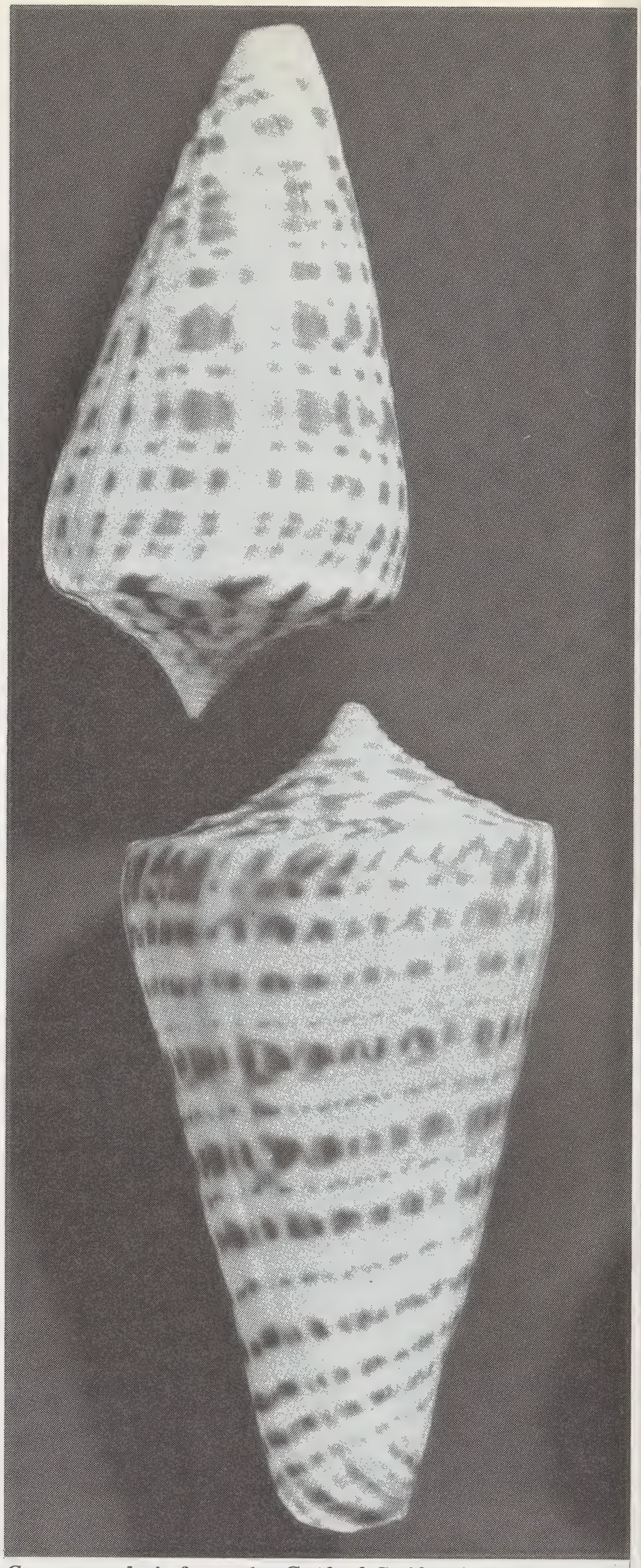
It was 1896, 60 years later, before two more specimens were taken, this time on Ceram Island, Indonesia. After another 60 years, in 1956, another was collected on Corregidor. The pace was accelerating; the next find was discovered only six years later, in 1963. Since then, as hitherto little-explored areas have become accessible to more and more people with more and more elaborate diving and collecting equipment, the number of specimens has proliferated, but *Conus gloriamaris* remains a rare shell. By 1967 the total number of recorded specimens had reached 63, not including eight shells known only from published reports and five that were casualties of World War II. The total of 63 specimens does include one specimen no longer in existence – a specimen smashed by a hammer in the hands of playful children.

And in spite of the continuing discovery of specimens, the glory-of-the-seas cone is still much coveted. A beachworn shell, valueless to either scientist or dedicated collector, sold for $100 as recently as 1966, and a damaged but live-collected shell brought $700. Many have changed hands several times. The *Conus gloriamaris* now in the museum at Ft. Myers, Florida, sold once for $300 and again for $1,200. The record price for a single transaction, $2,000, was paid for a shell now at the Academy of Natural Sciences in Philadelphia.

Noted for their beauty, the cones demand additional consideration when we view the accumulating reports of human injury. Yet the stinging of a human by *Conus* is always defensive. Almost without exception, injuries have resulted from careless handling of the shell. The animal has merely retaliated with its only weapon, its venom apparatus – the organs with which it procures its food.

By the middle of the eighteenth century, it was clear that cone shells were remarkable for more than their handsome appearance. Analysis of stomach contents of preserved specimens had shown that some cones feed on fishes. How a snail, sluggish by definition, could capture such agile prey posed a great puzzle. The consistent finding of worms in the stomachs of other conids hardly lessened the mystery – many marine worms are active animals. Not until the middle of the twentieth century was there any understanding of the way in which cones pursue and capture food.

Alan J. Kohn, now of the University of Washington, the foremost contributor of information on the genus, became interested in the ecology of *Conus* in Hawaii where 30 or more



Conus regularis **from the Gulf of California (at top), and** *Conus spurias atlanticus* **from the West Indies, similar in appearance, come from widely separated geographic areas.**

species may occur on a single reef. Food, of course, ranks high on any list of bio-requirements, so Kohn first turned his attention to the diet of the multitudinous Hawaiian cones. He found that both the integrity and distribution of each of the sympatric species were largely determined by the preferred food, and that each species of *Conus* on a single reef has its own niche – a niche defined by its species diet. The different species were not in competition for food.

All species of *Conus* observed to date are predatory carnivores and the diet of many is restricted to a certain type, or even species, of prey animal. Some, such as *C. striatus* and *C. catus* in the Indo-Pacific and *C. purpurascens* in the Gulf of California, feed only on fishes. As a general rule, the fish they choose are small, relatively sedentary, intertidal species roughly equal in length to the cone's shell, although considerably larger fish are occasionally consumed.

A second group, typified by the tropical *Conus textile,* feeds solely on other marine snails, either swallowing the prey whole and later regurgitating the shell or ingesting only the soft parts of the victim. Again the diet may be restricted to a single prey species. One cone, *C. marmoreus,* appears to feed solely on other species of cones.

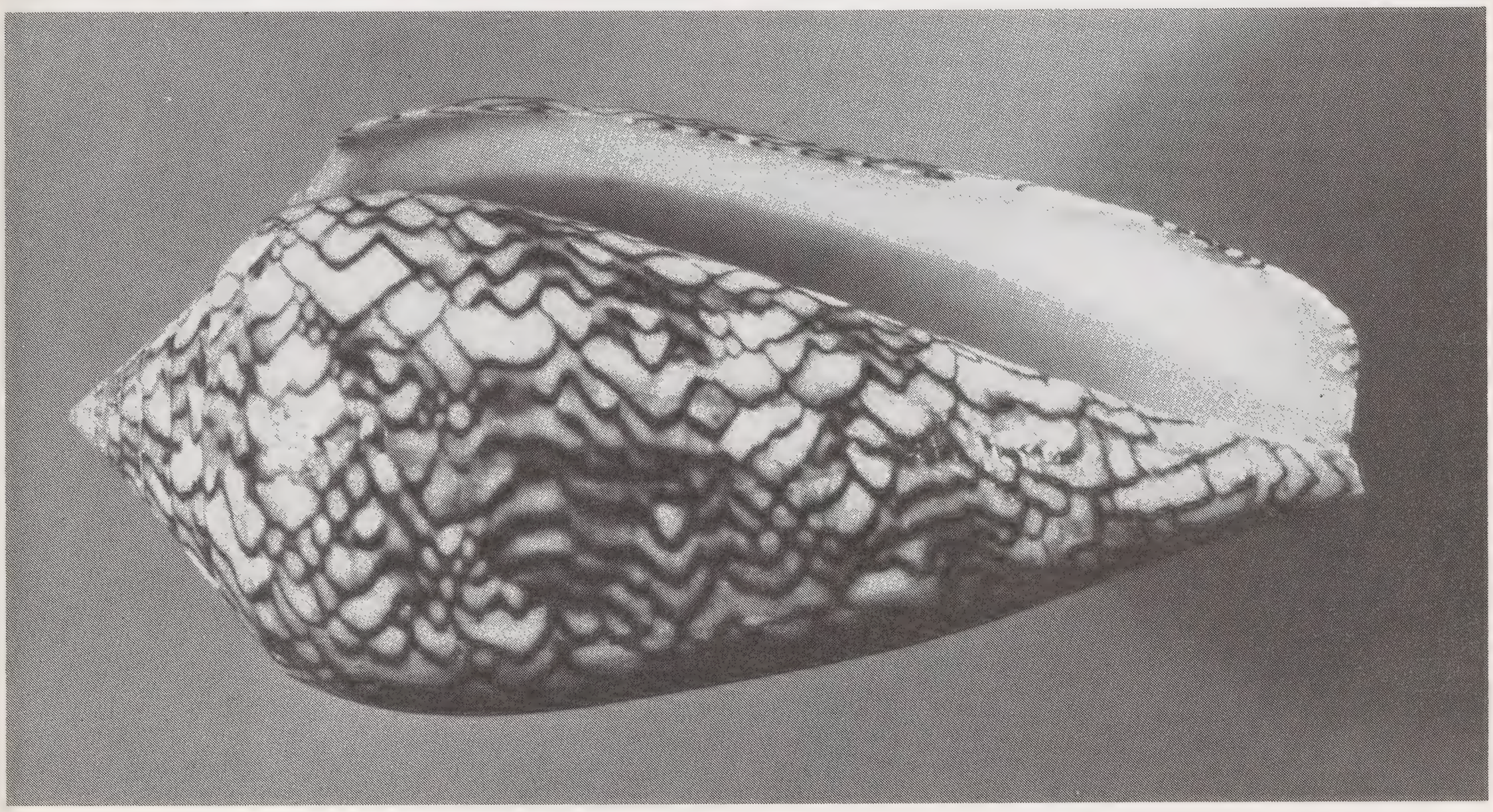
The majority of conids whose food has been investigated prefer worms or worm-like marine animals. Many conids will feed on only one species of worm, but a few are less fussy in their taste.

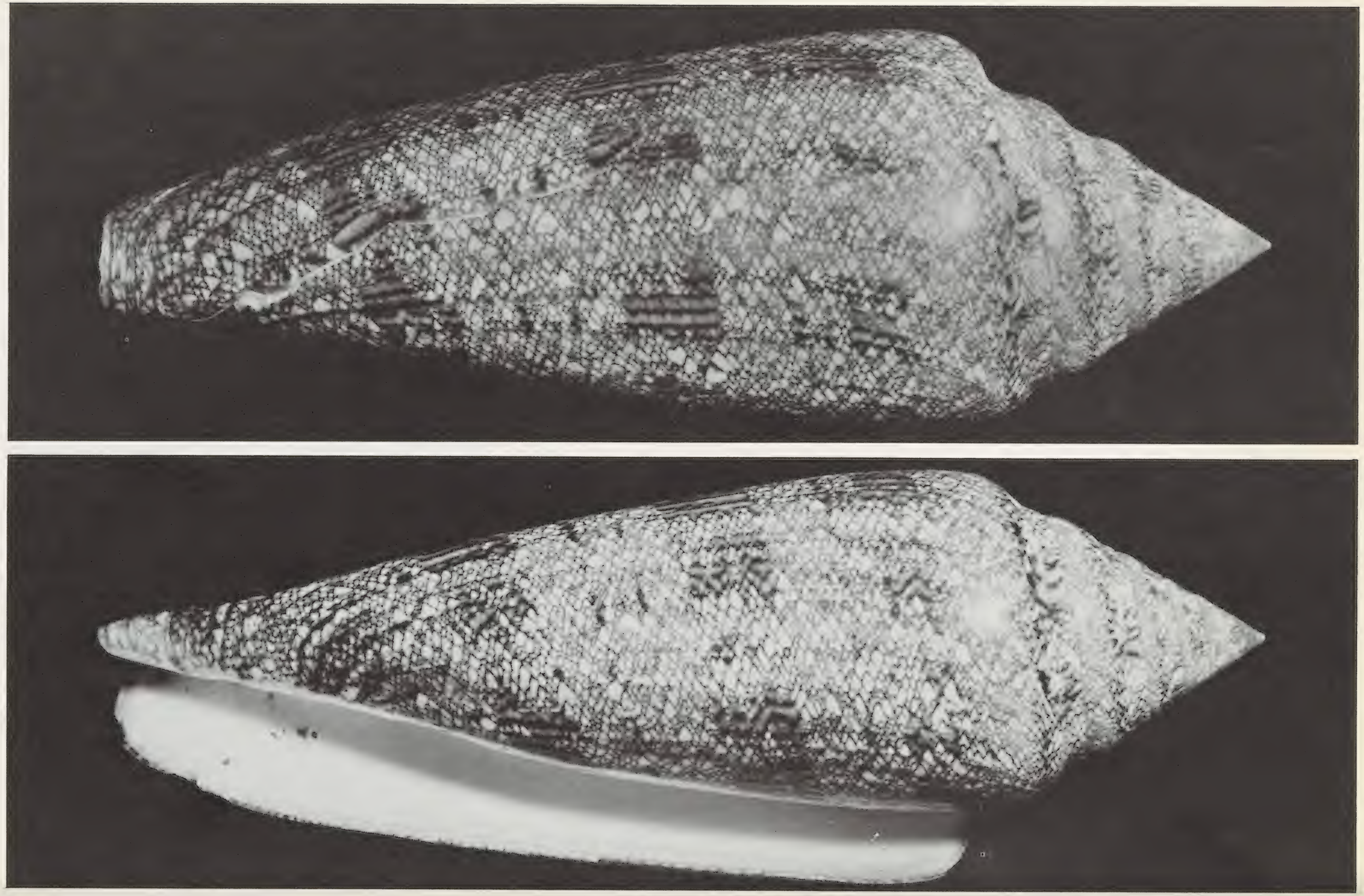
The least finicky of all is *Conus californicus,* one of the few non-tropical species. It is the only representative of the genus on the Pacific coast of North America, where its range extends from the Farallon Islands off San Francisco to the tip of Baja California and occasionally around into the Gulf of California. Although it has no documented record of human stingings, this little cone has been much studied, initially because of its availability to scientists in the United States.

Paul R. Saunders, investigating the venom of tropical cones at Scripps Institution of Oceanography at La Jolla, California, was faced with the problem of supplying his imported specimens with locally available food. Molluscivorous *C. textile* found the California cone a tasty morsel. When Dr. Saunders returned inland to the University of Southern California to continue his research, he took both his experimental cones and their food supply with him. And, as the food supply must be kept healthy, he asked me to undertake a study of the diet of *C. californicus.* I found that, although showing a distinct preference for worms, the California cone is also piscivorous and molluscivorous. Its menu included 28 species. In the laboratory it ate earthworms and frozen fish flakes and even turned scavenger when presented with material that was not badly decayed.

Kohn considers that dietetic specialization by the many sympatric Hawaiian cones is possible because of the stability of their environment. This assures a constant supply of the special item, whereas seasonal changes in the temperate regions

Below: *Conus textile* from the South Pacific. On page 12: two views of *Conus gloriamaris,* the famous and much-coveted glory-of-the-seas cone.





inhabited by *Conus californicus* affect the availability of prey species, making flexibility in choice of food a distinct advantage or even, perhaps, an absolute necessity.

The way cones feed is as unusual as their diet. Organs of the typical gastropod digestive system have become uniquely specialized and associated in a complex known as the venom apparatus. This consists of the venom bulb and venom duct, the radula and radula sac, and the anterior portions of the digestive tract, the pharynx and proboscis.

The mechanics of the apparatus' functioning are no more amenable to observation than is the innervation of a muscle. The soft molluscan body is hidden within the shell, coiled around the inner helix, and firmly attached to the columella. To observe the body, the shell must be smashed and the soft parts extracted. Hence, with only non-living material available for study, the operation of the apparatus is still a subject of speculation. We do not yet understand every detail, but the general picture, pieced together from studies of gross anatomy and histological sections, seems clear.

Examining the extracted body, it will be seen that the anterior part is covered with the mantle. Lifting this reveals the head end of the cone, with the venom apparatus tucked compactly in and around the esophageal region. When the organs comprising the apparatus are dissected out, the thickly-muscled bulb is easily the most conspicuous component. Small amounts of venom may be manufactured in it, but the bulb is neither the major venom-secreting organ, as was thought for many years, nor a vessel for its storage. Instead, it functions as a syringe, a hydraulic propulsion mechanism for forcing venom through the duct and into the radula tooth.

The bulk of the venom is manufactured in the internal walls of the duct, a very fine tube that runs forward from the bulb, looping and coiling around the other organs of the apparatus. Stretched out, its length may be five times that of the shell. Current research is pointing to differential sites for the most potent venom. In some worm-eating species, the most toxic venom is, as would be expected, in the anterior part of the duct; in some fish-eating species, it lies, oddly, in the posterior part. At its proximal end, the duct enters the pharynx, a short section of the anterior gut encircled by a powerful nerve and muscle ring.

The radula sac also opens into the pharynx. The radula is the most consistent diagnostic feature distinguishing molluscs from all other animals. The typical gastropod radula is a rasping organ, a thin chitinous ribbon to which are affixed file-like rows of teeth, their number and form genetically determined for each species. In *Conus,* this pattern has been unrecognizably modified. There is no ribbon, and the abrading teeth have remarkably evolved into the organic equivalent of barbed hypodermic needles, the darts. Their number, size, and shape differ for each species of cone. But always, the harpoon-like darts lie in two bundles, shining through the translucent walls of the asymmetrically biramous radula sac. The larger bundle of darts, in the longer arm, are in various stages of development and point toward the blind end of the sac. The short arm, aptly termed the quiver, contains a smaller number of fully-formed darts, all pointing toward the opening into the pharynx, ready for use.

The darts themselves are intricately rolled, hollow tubes of chitin, glistening and transparent, each attached by a ligament to the wall of the radula sac. They are variously barbed and serrated in the different species. Interestingly, there is no relation between number of barbs, tooth size, and shell size: the dart of an average *Conus californicus,* 25 millimeters in shell length, and the dart of a 230 millimeter *C. millepunctatus* may be less than a millimeter long; the two-barbed tooth of a 40 millimeter *C. striatus* may measure one centimeter. That a relationship does exist between type of dart and type of diet is becoming apparent from current studies.

The portion of the digestive tract extending forward from the pharynx is the proboscis. It is a prehensile, highly extensible double-walled tube, its outer wall continuous with the lining of the buccal cavity. Contracted, it looks much like a concertina; as it extends, the folds smooth out. Poised at the tip of the proboscis, probably held by a collar of muscle, is the deadly dart.

We can only conjecture how the proboscis is armed. A plausible theory is that it is retracted into the pharynx, its tip rolling in and back — much like the finger of a glove that is being turned inside out. After picking up a dart positioned in the pharynx or at the juncture of pharynx and radula sheath, it unrolls, the tooth in position for firing. Peristaltic action of the radula sac and movement of the dart by the sac's epithelial cilia may facilitate the procedure.

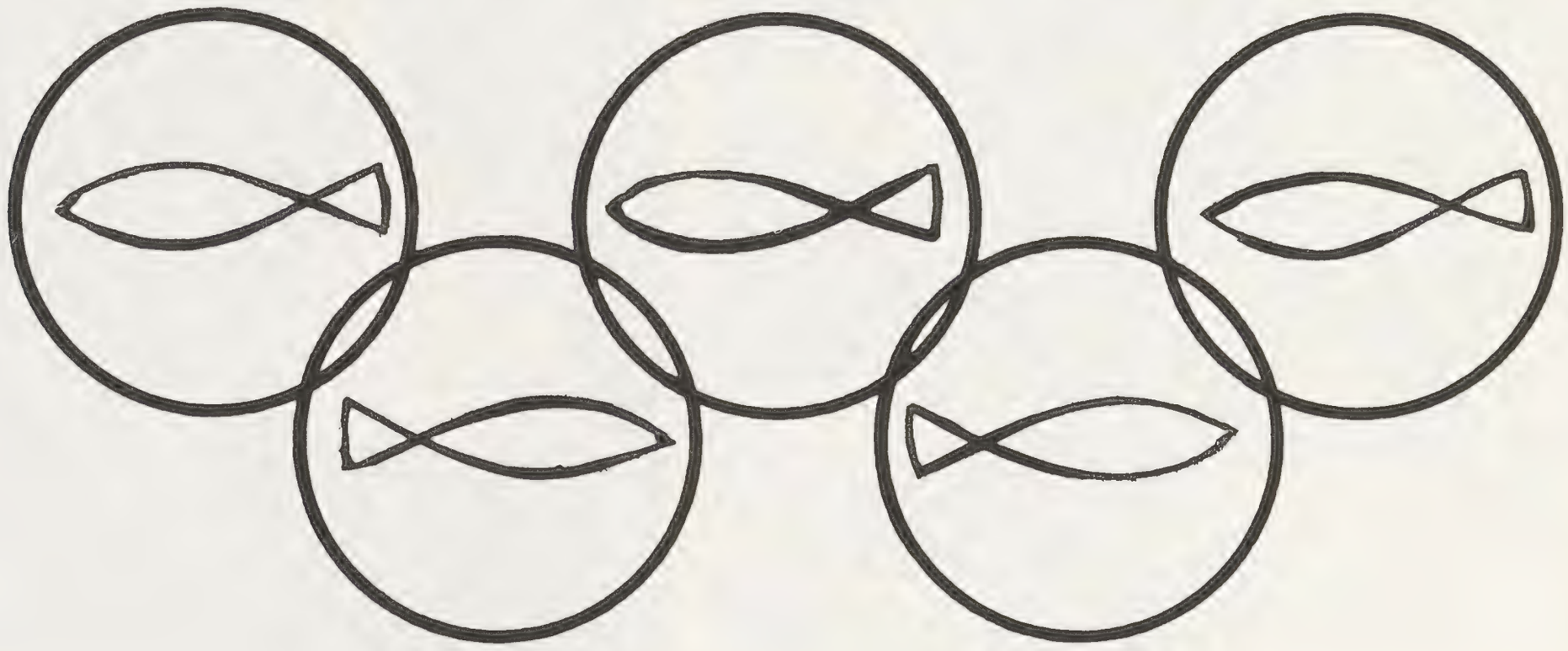
Except during the feeding process, these organs are inactive and kept well within the shell. Then, as we shall see, they are brought into play with spectacular results.

(Part Two will be published in a later issue.)

CHILDREN'S ZOO

Photographs by William Meng

THE OLYMPIC MUDMINNOW



by U. Erich Friese

In 1921 John H. Winslow, who at that time was game warden of Grays Harbor County in the state of Washington, found some small fish in a drainage ditch near Satsop, one-half mile north of the Chehalis River. Since the little fish of about two inches in length were strangely unfamiliar to him, he preserved them and later sent them for identification to the College of Fisheries, University of Washington, in Seattle.

Through a series of unexplainable mishaps, however, these specimens were misplaced and remained so for about seven years. However, in 1928 Leonard P. Schultz, and ichthyologist then associated with the College of Fisheries, came across the preserved specimens from Satsop. When early in 1929, a number of live specimens was collected in the same area, Schultz became aware that this was an entirely new and thus far unknown species of mudminnow. Furthermore, Schultz was familiar with the world-wide distribution of freshwater fishes, so he recognized this ichthyological find was significant from a phylogenetic point of view.

The occurrence of a mudminnow in western Washington is unique both from a biological and geological standpoint. It is in an intermediate position in the evolution of fishes between the Alaskan blackfish (Family Dalliidae) and the eastern mudminnows (Family Umbridae). Schultz established a new genus, *Novumbra hubbsi* for the western or Olympic mudminnow and placed it in a new family, Novumbridae. In its evolutionary position, the Olympic mudminnow is a representative of an ancient fauna, which extended across North America before the Rocky Mountains were formed. Fossil remains from this fauna can be found in the Eocene Green River Shales of Wyoming.

Most likely the mudminnows have had a much wider distribution in ancient times that is now evident in the North American fish fauna. Today, one species of mudminnow is found in central Europe, two in eastern United States, and the other on the terminal moraine of the Old Vashon Glacier in western Washington. What could have happened that isolated the Olympic mudminnow by thousands of miles from its nearest relative? In order to find the answer we have to look at the ecological zoogeography of *Novumbra hubbsi* in relation to the geological events that took place in western Washington many thousands of years ago.

The Cascade Mountains separate the state of Washington climatically and faunally into two distinct regions, eastern and western Washington. Including the Olympic mudminnow, there are 11

species of strictly freshwater fishes found in western Washington. While most of these species have a fairly wide distribution within this region, the habitat of the Olympic mudminnow is confined to a rather narrow range. A few specimens have been found in the Deschutes River draining into Puget Sound; however, these may well have been introduced artifically. *Novumbra* has never been reported from other rivers belonging to this drainage system. The center of abundance of the Olympic mudminnow is on the west coast of the Olympic peninsula, where its habitat extends from the Chehalis River system north to the Quinault River.

It has been hypothesized that the absence of this species from the extensive lower Columbia River and the Puget Sound drainage system (both of these river systems are in close proximity to the present day range of *Novumbra,* and logically they should have been invaded by this species) is a result of the permanent nature of a Columbia-Chehalis drainage divide during the Pleistocene epoch. A sequence of four major glaciations occurred in the Puget Sound region at that time. During the last glaciation (about 15,000 years ago), ice advanced into the Puget Sound lowland and thus created an effective barrier *between* the Chehalis River and the Columbia River. This barrier could not be penetrated by the then existing fish fauna. However, since most of the Chehalis River remained ice-free, it was then available as a refuge for fishes when all other river systems to the north and south were glaciated.

Upon recession of the ice most species were apparently able to spread out again, except *Novumbra.* Because of very definite behavioral preferences, this species remained in its present range. Other habitats of the Olympic mudminnow, as well as actual fossil records of this fish, may have been destroyed by earlier volcanic activities once so prevalent in this area.

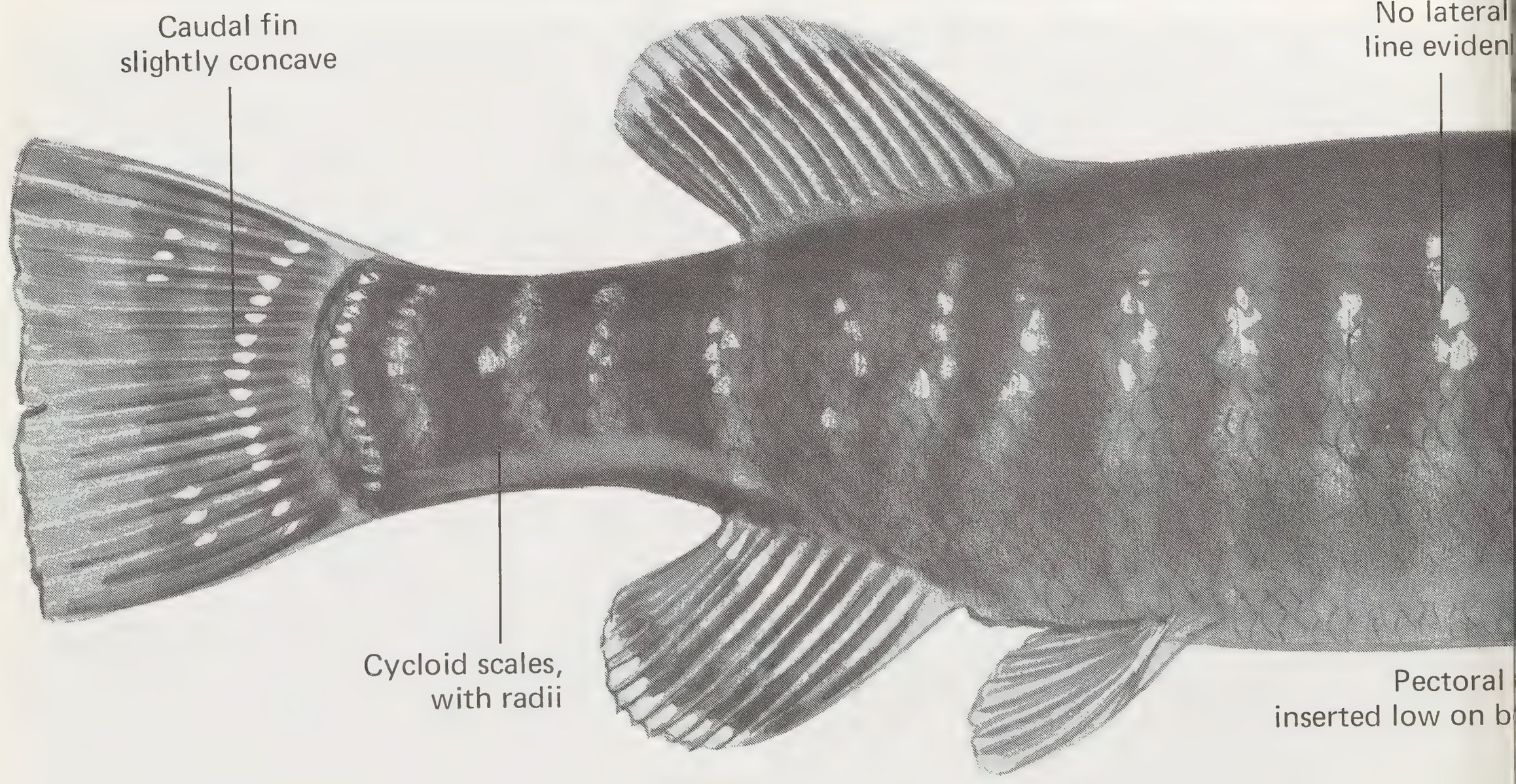
In 1967 this author had the opportunity to accompany Dr. John W. Meldrim, currently the leading researcher on the ecology and zoogeography of this unique fish, on a field trip to collect some Olympic mudminnows for laboratory studies. A fifty-minute drive from the College of Fisheries in Seattle took us to the west coast of the Olympic peninsula. After a scenic ride on State Highway 9 along the sandy beaches of the Pacific Ocean, a shallow drainage ditch appeared intermittently along each side of the road. Eventually the ditch widened into a continuous body of water. We stopped and unloaded our gear – sturdy hand-nets, buckets, jars, and waders.

While wading through the murky water, we sank up to our knees in foul-smelling mud. We swept the nets through the water along the edges of the ditch, which was overhung with thick underbrush. That was where the Olympic mudminnows were supposed to hide. Our efforts were rewarded in short order. Almost every haul produced a few small fish, each about two inches long. There appeared to be two different types.

The Olympic mudminnow, which occurs only in western Washington, is found in drainage ditches along highways.

OLYMPIC MUDMINNOW

2"



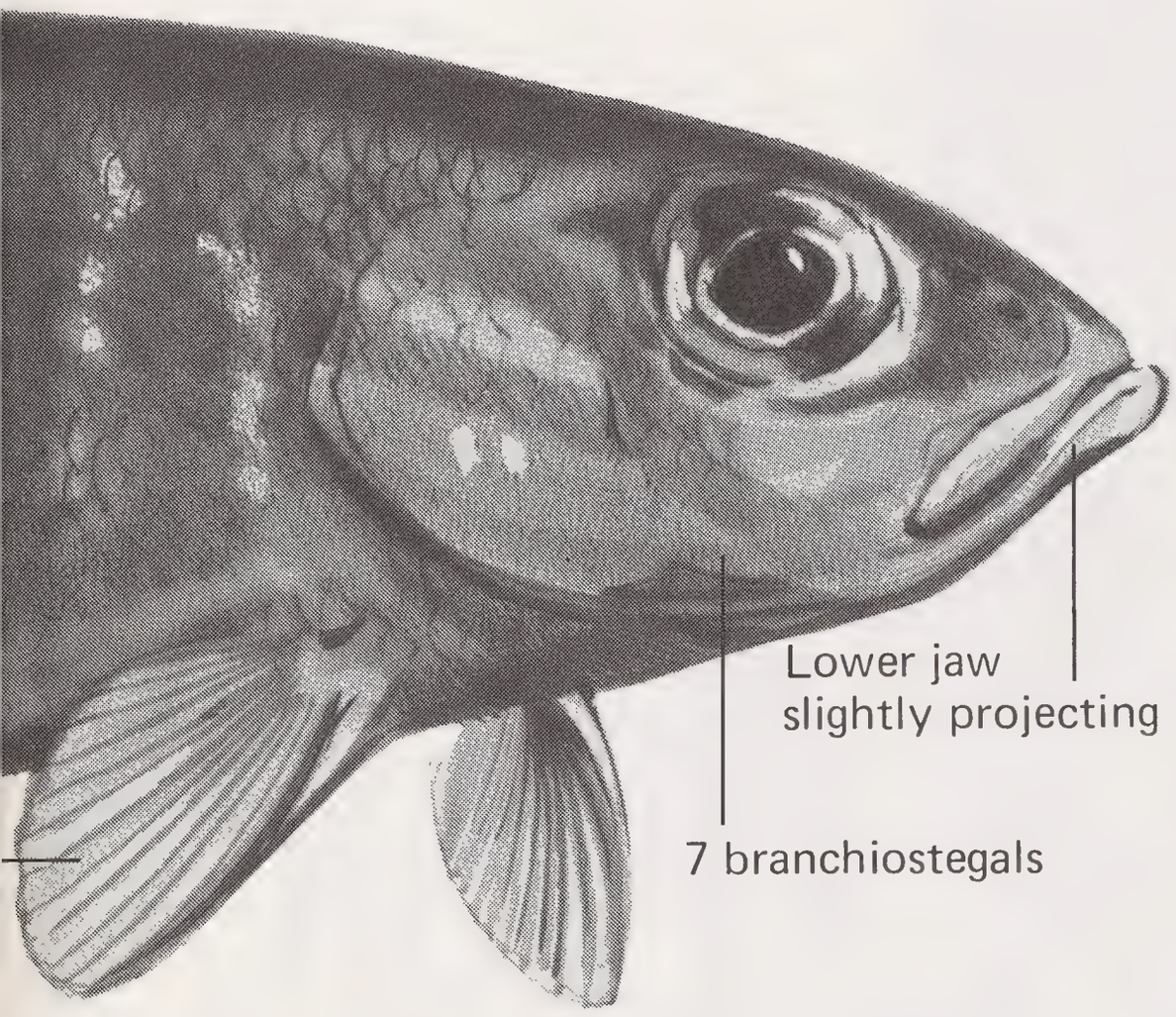
One was dark blue – almost black – and it had about 15 to 20 irregular, vertical bands of sky-blue spaced along the sides of the body. The fins were generally black, while the dorsal and anal fin had a bright, whitish-blue margin along the outer edge. The other type of fish seemed somewhat similar in appearance although it was not as brilliantly colored. Basic coloration was muddy brown, with the vertical bands only faintly indicated.

Dr. Meldrim explained, "Both fish are Olympic mudminnows, *Novumbra hubbsi.* The brightly-colored specimens are the males and the plain brown ones are the females."

On our way home Dr. Meldrim revealed some of his latest findings on *Novumbra* and his reasoning as to the extremely limited range of this species. "The Olympic mudminnow prefers quiet water, with a mud substrate and dense aquatic vegetation," he said. "It has a surprisingly wide tolerance for temperature extremes (from 0^{o}C. to about 30^{o}C.) and it can live at oxygen levels so low that they would be lethal to most other fishes. It appears, however, that this species is very selective as far as salinity and water current are concerned. This ultimately may have limited the distribution of the species."

Dr. Meldrim indicated that there are certain intraspecific variations between different populations of *Novumbra* even within such a narrow range. The Chehalis River populations are distinctly different by scale count and color intensity from those of the northern Quinault River system. A certain degree of dispersal, rather than strict genetic isolation, seems to be demonstrated by the natural occurrence of transitional forms in the region between the two major river systems.

Although no commercial importance is attached to this extremely attractive little fish, its mere existence – inherently difficult and complicated by its narrow distribution – is being further impaired by man's never-ending ambition for expansion. The construction of State Highway 109 cut right through some of the streams and ponds in that area and thus considerably changed the natural habitat of *Novumbra.* Current efforts to widen this road by filling many of the ditches occupied by the mudminnow further threaten *Novumbra* populations. However, if the reservation of the Quinault Indians to the north is not commercially exploited, some of the natural habitats of the Olympic mudminnow can be preserved for this ichthyological relic from the distant past.



TALAPOINS

by Amelia Segre

One of the more popular Monkey House exhibits at the Bronx Zoo over the years has been the talapoin family group *(Ceropithecus talapoin).* Visitors, especially children, are delighted by the almost chaotic chasing, wrestling play, and acrobatics in the talapoins' cage; and parents enjoy showing their children monkey mothers with babies.

However, visitors rarely have the time to observe the social order which underlies the apparent chaos in the talapoin group. It is not easy to see, for the talapoins are small and quick, and most individuals look alike to the untrained eye.

The present family group exhibited at the Bronx Zoo consists of nine individuals, including an adult male and three females captured in West Africa, and five youngsters which were born in the zoo. The oldest offspring is an adolescent three-year-old male, followed by a two-year-old female, two yearling females, and an infant born in June of 1969. This family represents the basic unit of a talapoin's social group as it exists under natural conditions in West Africa.

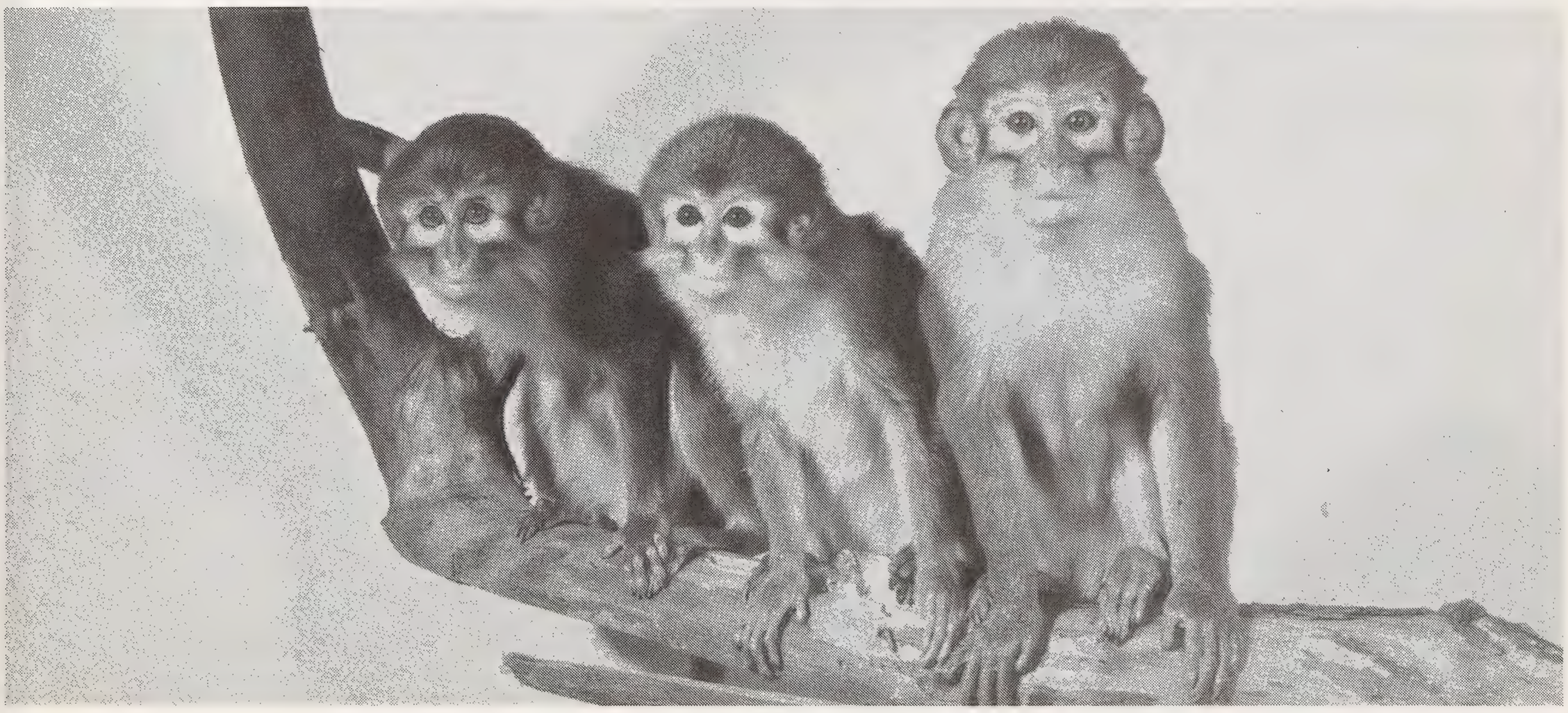
Under field conditions in second growth and mangrove forests of Gabon and Cameroon, talapoins are difficult to observe because of the dense vegetation and the monkey's relatively small size and quick movements. Thus, information on their natural history and behavior is rather sparse. Talapoins are known to live in groups of 50 or more individuals, consisting of several adult males and females and young of various ages. Groups have home ranges and traditionally return to the same sleeping sites or "dormitories" each night. The talapoins are sometimes seen in association with two other primates having similar habitat preferences, the moustache monkey *(Cercopithecus cephus),* and the mona monkey *(Cercopithecus mona).* They are also associated with a bird, the hornbill, *Tropicranus albocristatus,* which apparently feeds on fruits which the monkeys open and discard, half-eaten.

Like many other primates, talapoins in the field have a mating season and a corresponding birth season, six months later. Both seasons coincide with cool dry periods following the two rainy periods. The other monkey species in the region show an almost identical seasonal mating and birth pattern.

Talapoins are certainly numerous. They are one of the few primate species in Africa presently increasing in numbers. The number of mona monkeys, in the same type of habitat, is also probably growing. It is thought that the increasing amount of secondary forest, following both logging and abandonment of plantations, contributes to the success of these two species. In addition, the talapoins are not hunted and seem to survive quite well in the vicinity of villages. The talapoins benefit from the presence of man in that at least one new food source, manioc root, is available to them. They obtain the root by raiding small ponds in which the villagers soak it to leach out poison and make it palatable.

At first glance, monkeys look alike to most people. Actually, each individual has distinctive characteristics that distinguish it from its fellows. As in many other primate species, the females all show periodic color change and swelling in the rump when they come into estrus, or sexual receptivity.

To the public, the talapoin exhibit is an entertaining scene, but to the scientist, it is also an educational laboratory.



In dense forest, it is literally impossible to see the whole group at once, and it is just as difficult to keep track of one individual for more than a few minutes at a time. Therefore, for close detailed observations of social behavior, a small group of animals in a naturalistic zoo setting has many advantages.

The males are slightly larger and heavier than the females. The subadult male is much fatter than the adult. Each female has a distinctive pattern of facial hair, especially along the brow line, and this has enabled me to name each female in the group I am studying according to its facial hair patterns. "Ruff" always looks disheveled and has a low brow line; "Round" always looks neat and trim, and has a narrow white band along her brow line.

The juveniles are much harder to distinguish from one another because they seldom stay still. Therefore, I resorted to squirting them with black hair dye from a water pistol. All the juveniles were marked with black splotches randomly distributed on their bodies.

It was soon apparent that individuals of different age and sex classes tend to do different things. The adult male spends most of every day quietly sitting on one of several high branches, surveying activities occuring inside and outside the exhibit. He always seems to gaze into the distance, except when something exciting happens near him. This inactive "watch-dog" role for the male has been observed in several other primate species, including the vervet, *Cercopithecus aethiops,* and the black and white colobus, *Colobus guereza.*

A talapoin mother and child is always an appealing scene.

The male occasionally punctuates this routine with bursts of exaggerated yawning which display his worn teeth. These yawns are not directed at another individual. The other talapoins rarely yawn. However, I have seen the leader female of a group of captive talapoins lacking an adult male yawn in the same manner as a male. Yawning seems to be associated with the leader role and occurs when the animal is tense rather than relaxed and sleepy.

Occasionally the male in my study group approaches any one of the females to groom or to be groomed. He also engages in long "wrestling and boxing matches" with his son. It is the young male who usually initiates the matches, although the adult male invariably assumes a higher perch and thus always has the advantage. So far the wrestling and boxing matches are clearly friendly play, but the situation may change when the subadult male reaches full maturity.

When it comes to supervising family quarrels, usually caused by the younger male, the adult male merely watches the action closely; however, if the females cannot handle the male youngster, the adult male chases and threatens him, open-mouthes, with a head bobbing gesture, sometimes accompanied by a series of explosive coughing sounds.

The subadult male, named "Norman" after a teen-age acquaintance of mine, is a terrible tease, constantly chasing, poking, and otherwise harassing the females. They may threaten him and chase him, but he usually continues the game. Norman wrestles, bites, and plays chasing games with the juveniles. Although he is much bigger than his sisters, he rarely plays so roughly that they cry or screech. If a juvenile should screech and run to touch one of the adults, both may lip-smack in Norman's direction; the chances are that Norman will be chased by one of the females or the adult male.

Norman has some peculiar behavioral idiosyncracies. I do not know whether they are related to the fact that he is cage-bred or that he is passing through an odd phase of development. For example, he is the only talapoin I have seen who sits on a branch the way humans do, either straddling it with legs dangling down, or with both legs hanging down on the same side. At other times when he is sitting quietly, he holds his hand up at eye level and stares at it, cocking his head from side to side. Sometimes, as if in sheer excess of energy, he races

around the cage several times, noisily landing and bouncing off branches.

The females each have strong individual personalities. Yet each female has more in common behaviorally with her other female age-mates than with males or juveniles. Like the males, the females spend most of the day sitting quietly; but rather than gazing into the distance, they seem concerned with close detail. They supervise the activities of their offspring, nurse, groom, and otherwise comfort the young, and spend much time grooming themselves and each other. Their behavior seems to be determined in part by their reproductive cycle and whether or not they have infants. During late pregnancy, for instance, the females tend to become rather sluggish in their movements and slow to initiate any social interaction. Yet they still groom, like all the other females. A mother with an infant up to weaning age becomes the center of attention for the whole group, including the adult male, and the recipient of an extraordinary amount of grooming.

Social grooming, or inspection of one animal's fur by another, is the most obvious friendly social interaction to be seen in this species and in many other species of primates. It is most frequent among females. Grooming consists of minutely inspecting the coat of another animal, using one hand to part the fur and the other to pick or pluck at particles. Occasionally the lips may be brought to the skin and a dead hair or piece of dirt removed. Little chewing movements may accompany grooming. Grooming progresses from the head and face along the back, flanks, and limbs, to the tip of the tail. Of course, it may begin or be interrupted at different parts of the body.

Social grooming in talapoins may be initiated in one of several stereotyped ways. The potential groomer may approach another individual and pull its head down, grooming the crown. Subsequently, the animal being groomed may flop into a prone, relaxed position. Under other circumstances, the groomer may approach another individual from the side or from the rear, and begin grooming the flank or tail. This approach is used when there is an element of fear or uncertainty on the part of the groomer. Ruff used this tactic to groom Round after the new infant was born, since Round invariably threatened and chased any who approached her.

Alternatively, the groomer may be approached by the potential partner, which flops in a prone position at right angles to the groomer, with face averted. A variation of this form of "presenting"

Grooming is an important social function for talapoins. Overleaf: a youngster carefully grooms its own tail. Above, a female grooms a mother with an infant.

for grooming is to flop with head toward the potential groomer. Usually the face is averted, but Norman and another juvenile often glance directly into the groomer's face and then gaze off to the side.

Superficially, social grooming appears to serve a cleaning function, since it occurs mainly on parts of the body that an individual cannot reach for itself. However, it cannot serve merely to clean the fur, since some animals are groomed more than others. In addition, grooming pairs do not occur at random. Mothers and infants are frequent grooming partners, but among adults certain grooming pairs are common and others are rarely seen. For example, for almost six months Ruff and Round never sat near each other and never groomed each other. Ruff now frequently grooms Round, although she is never groomed by Round in return. Round grooms only the males and her own infant.

The new social relationship between Round and Ruff emerged after the birth of Round's infant this past year. Ruff, who was not pregnant and had a yearling which occasionally still nursed from her, was greatly attracted to the new infant, as were the other animals in the group. However, while the interest of the other monkeys waned as the infant grew older, Ruff remained completely

absorbed by the youngster. She would sit for hours about two feet from Round and the sleeping infant.

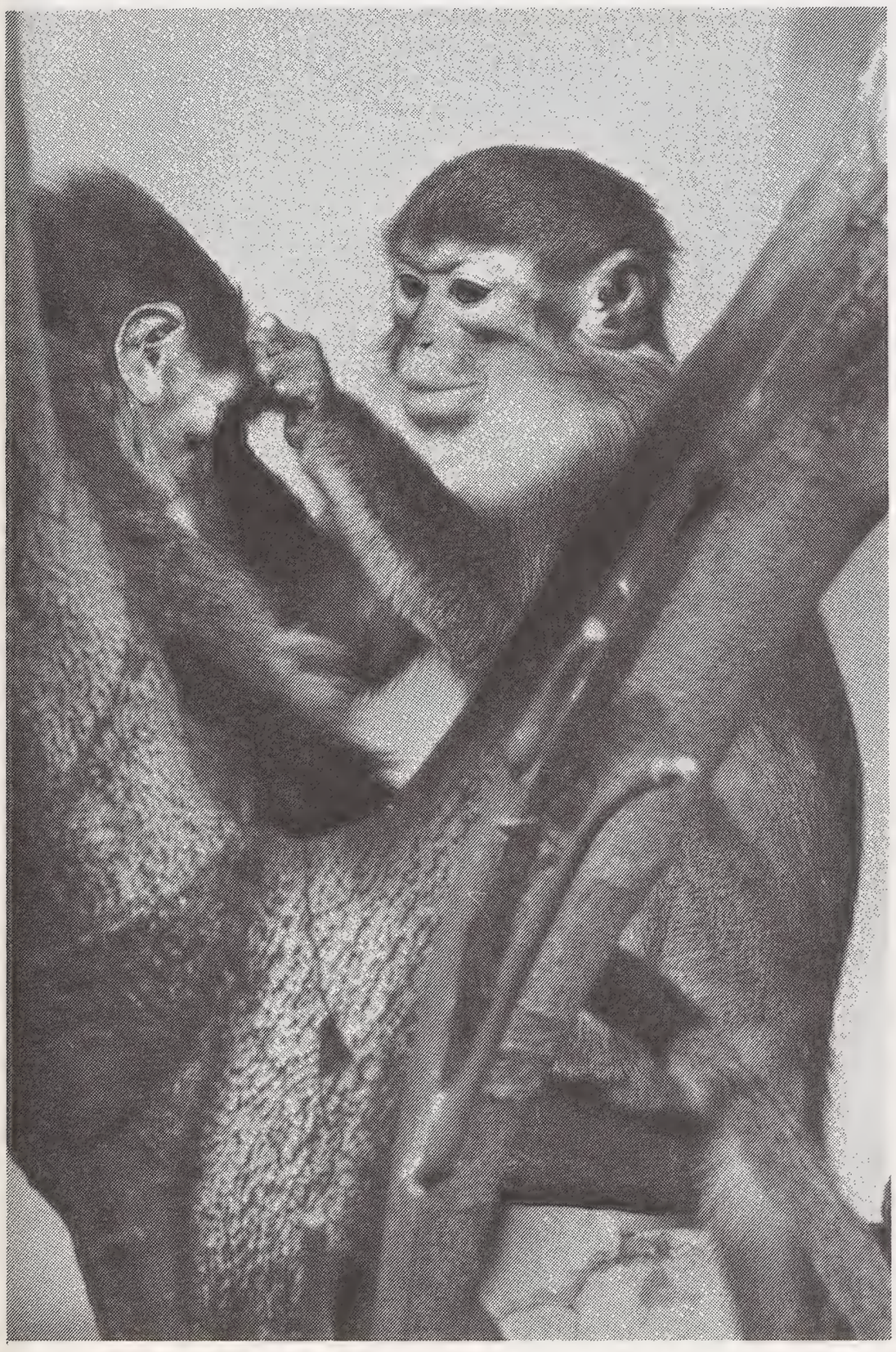
As the days passed, Ruff crept closer and closer to Round. She would sneak up and peer over Round's shoulder at the infant, reaching for its tail which was out of Round's sight. Every time Round moved, Ruff would jump away. As Round became less protective toward the infant at about eight weeks, Ruff was actually permitted to hold and to carry it. Rather than approaching from behind, she would approach Round from the side and would sometimes touch or groom Round's flank, carefully avoiding meeting her eyes. However, it was Round who initiated long grooming sessions by presenting to Ruff, lowering her head or flopping sideways in front of her. Thus, although the initial bond between the two females may have been the attractiveness of the infant, Ruff and Round seem to have become one-way grooming companions. It will be interesting to see how stable this new relationship is.

Aggressive behavior is evident among the females. When Round was pregnant, and for two months following the birth of the infant, she gave the open-mouthed threat and chased or struck out at anyone who approached her. She tolerated only her own yearling and Nil.

Nil is probably the least predictable of all the group. With equal frequency, she may threaten or may be friendly toward another monkey. As a consequence, there is usually an ambiguous response to her approach. The juveniles especially may retreat or cringe, then return, flopping in the "present" posture for grooming. They are quick and can avoid her if her subsequent behavior proves to be unfriendly. Sometimes she will give all indications of being friendly, including grooming for several minutes; but she might follow this up with a nasty bite in the small of the back and by giving repeated explosive coughs like those described for the male. Ruff is the least aggressive of the females; although she may grin at another animal, baring the teeth with lips retracted, she usually retreats at the same time. She often retreats or cringes when others approach her.

The three juvenile females occupy their days by playing and exploring the cage, alone or in pairs. They investigate and manipulate objects, peer into holes, retrieve scraps of food that might be left after the cage has been cleaned. They rarely groom each other, but may participate in grooming with the adult females.

In grooming, one animal minutely inspects the coat of another, using one hand to part the fur and the other to pluck any particles.



Round's yearling daughter has an additional role. She very busily baby-sits her infant sister. She prevents the other juveniles and some adults from approaching the infant by frequently threatening and chasing them. She is almost as effective in this as Round is. She plays with the infant, sometimes pulling its tail, explores with it, and restrains it. Occasionally Round threatens or hits the yearling if the latter tries to pry the infant off the mother's belly. When both Round and the juvenile are distant from the infant, it is possible for the other juveniles to handle or to play with the youngster. Now that the infant is four months old, it plays with all the juveniles, frequently dashing back to Round, touching her, and running off to play again.

In conclusion, a consideration of each animal's activity in the talapoin group indicates that the animal's lives are quite orderly. An individual's non-social activities are predictable, as are its social interactions. Knowledge of an individual's age and sex give important clues to its potential behavior. But beyond that, knowledge of a monkey's genealogical relationship to other individuals as well as of "friendships" adds considerably to one's ability to predict behavior.

BALI AND ITS MYNAH

BY FREDERICK R. HARTMANN

Bali, that romantic island of dancing girls, verdant rice paddies, and soaring volcanoes, has always enjoyed a certain South Seas mystique in the minds of armchair travellers the world over. Deserved or undeserved as this reputation might be, a closer look at current conditions on the island will reveal that for all its natural beauty, it is not exactly a paradise for its wildlife population.

One of Indonesia's Lesser Sunda Islands, located immediately east of Java, Bali has 1,783,000 (1962) inhabitants crammed into its 5,561 square kilometers. This overpopulation is coupled with an alarming growth rate.

The resultant population pressures on natural resources have endangered those animals on the island which cannot readily adapt to man's altering of various ecosystems. The Bali tiger *(Panthera tigris balica)* is a case in point. The smallest of the races of tiger, and unique to the island, it is now virtually extinct. No reliable sightings have been reported since 1952. However, such evidence as tracks and spoor would seem to confirm the belief that a few tigers still survive in the heavily-wooded regions of the two national parks in the extreme western part of the island. Destruction of habitat by man was the initial villain here, with hunters finishing what the loss of habitat started.

Against this bleak portrait of human overpopulation, ruination of habitat, poaching, and public ignorance, hope may be found for the protection of Bali's wildlife in the history of Indonesia's conservation efforts.

In 1916, the Government of the then Netherlands East Indies established a magnificent network of nature monuments (wilderness areas) and game reserves (parks or management areas). Included were areas in the Lesser Sunda Islands. By 1938, ninety-seven reserves and monuments, incorporating approximately 1,431,000 hectares (4,500 square miles) existed. These areas were initially administered through the Government Botanical Gardens at Buitenzorg (now Bogor), and in 1935 the post of nature protection officer was created. Andries Hoogerwerf was the first man appointed to this position, and he held it virtually alone until Indonesian independence in 1949. Under his direction the total number of reserved areas had increased to 120 by 1947. Most of these areas had by then been placed under the official supervision of the Forestry Service; and, in 1951, after independence, a Department of Conservation and Wildlife Management was established as a part of the Forestry Service. By 1955, this department had a force of about 250 men who were charged with managing the reserves and handling nature protection activities throughout Indonesia.

It can be said that Indonesia has had a fine start in conservation with its system of reserves, botanical gardens, game laws, and national parks. The Indonesian Government has to the best of its ability in the face of most adverse conditions maintained this legacy and improved upon it.

It is within this setting that we should consider the present status of the Bali, or Rothchild's, mynah (*Leucopsar rothschildi*).

First described by Stresemann in 1912, it is one of the most beautiful members of the starling family. The bird presents a striking appearance – solid, snowy white, with black-tipped wings and tail. An interesting strip of bare, blue facial skin extends backwards from the bill and around the eyes. (Different types of wattles, crests, and bare areas of skin on the head are rather frequent on the starlings and are probably used in courtship.) The Bali mynah also has a crest, running from above the bill to the nape, the feathers of which can be raised at will.

As a group, starlings are ecologically diverse. Many species flourish in tropical jungles, while others, primarily in Africa and Asia, are birds of open country or scattered woodland. These birds, like *Leucopsar rothschildi*, do most, if not all, of their foraging on the ground.

The Bali mynah, in common with all starlings in general, may be described further as an Old World song bird of medium to large size. Endemic to the island, it is the lone species of its genus. This fruit-eating bird nests in tree cavities, but, unfortunately, very little else is known about its breeding habits in its wild state. Concern for the survival of the Bali mynah has been expressed in recent years – primarily because it occurs only on the northwest coast of Bali and on the small island of Nusa Penida, which lies just off the south coast of Bali. Curiously, the bird is not found anywhere in between these two locations. No satisfactory explanation has been given to explain this separation, but it is thought that some form of limited migration might be involved.

In order to more fully understand the particular evolutionary niche that the Bali mynah occupies, it is necessary to examine a fascinating natural phenomenom which is known as "Wallace's Line."

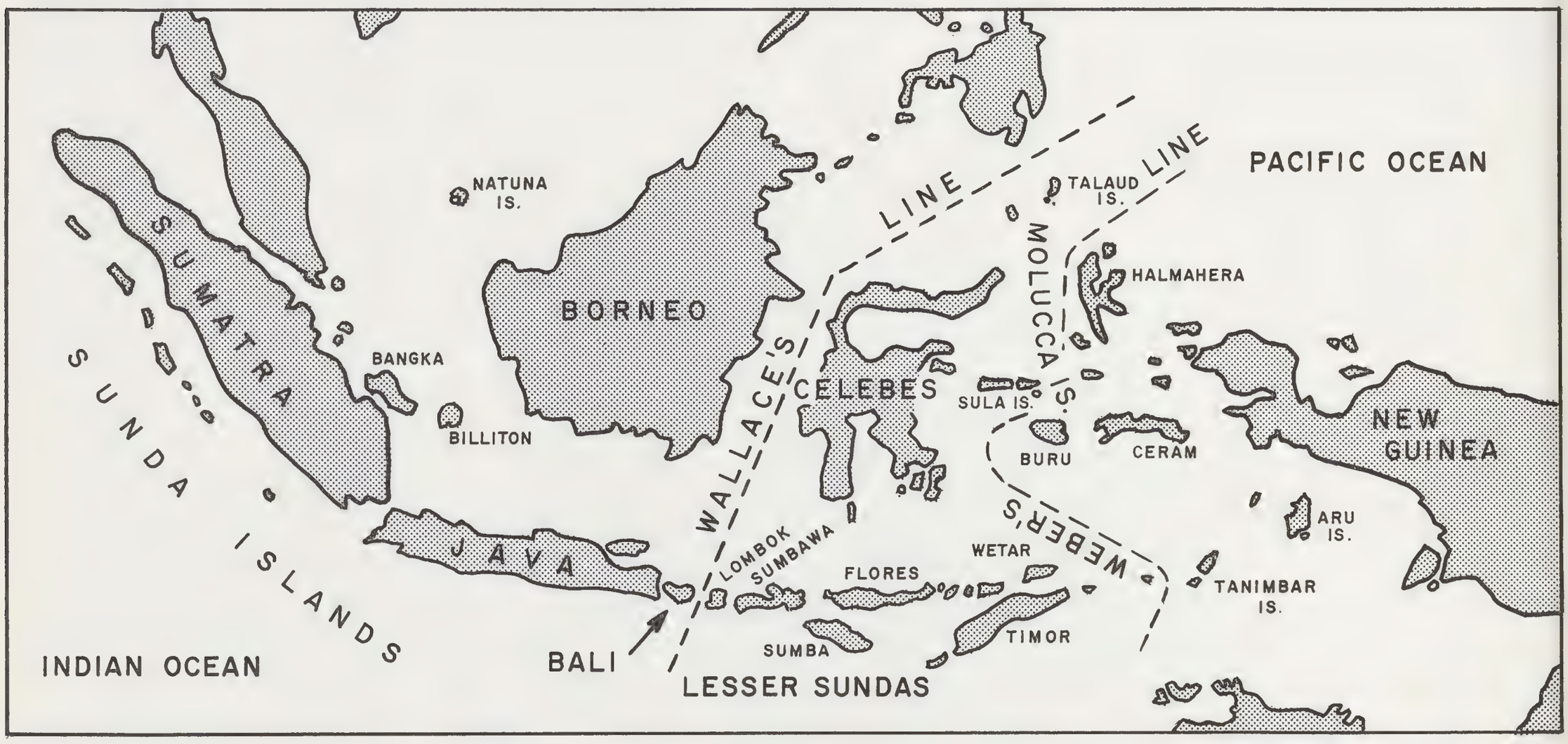
In 1860, the zoogeographer Alfred Russel Wallace, after extensive study in the area, drew a theoretical line that ran between Bali and Lombok (Bali's neighboring island to the east), between Borneo and Celebes, and between the Philippines and the Moluccas. It was known at the time that the faunas of the Oriental (Asian) and Australian Regions are extraordinarily different, and what happens where they meet in the Indo-Australian Archipelago has been the focus of attention for many zoogeographers throughout the years. (The difference between the faunas of Bali and Lombok, which are separated by a deep [100 fathoms] strait only about 15 miles wide, has received special emphasis.) The line Wallace drew was his attempt to specifically delineate the points of separation between the faunas of the two regions. Today, after a few modifications, the line is regarded as the beginning of a transition zone, rather than a sharp boundary. But it still retains its immense value as a reference point for zoogeographers.

To illustrate this delineation between faunas of two vast, complex and extremely important animal regions, consider that the Asian mainland has a huge assortment of strictly fresh-water fish. Most of these fish reach Sumatra, Java, and Borneo, but except for a few small cyprinids, they do not extend to Bali. In fact, Bali, with many streams, does not have any significant fraction of the Javan fresh-water fish fauna, although Java is Bali's immediate neighbor to the west.

The Oriental Region amphibians known to occur on Bali are two species of frogs. Many Oriental groups of reptiles do not cross Wallace's Line, while others do, for varying distances toward the Australian Region. An important point here is

that while a considerable part of the Oriental reptile fauna crosses Wallace's Line and extends towards Australia, it does so with progressive subtractions.

Many Oriental mammal groups are found on Borneo and Java, but only a few extend farther east. A large number of the Oriental mammal groups that reach Java do not reach Bali. These include flying squirrels, gibbons, the Asiatic wild dog, hairy hedgehogs, lorises, weasels, some genera of rodents, flying lemurs, otters, the leopard, a rhinoceros, badgers, and mouse deer. Some of the Oriental mammals that do extend to Bali but not to Lombok, include a tree shrew, two monkeys, a scaly anteater, two squirrels, the leopard cat, and



the tiger. Except for murrid rodents and bats, any of the Oriental mammals occuring east of Bali and Celebes probably were introduced by man.

The distribution of birds between the Oriental and Australian Regions is the most complex of all. There are many shared groups, transitional groups, and many groups which occur in only one region and which do not enter into the transition.

The difference between the birds of Bali and Lombok has been long emphasized by ornithologists. Almost all the bird species of Bali are Oriental. And nearly three-fourths of the birds of Lombok are still Oriental, even through Lombok is on the Australian side of the line. Interestingly, the dominant species are mostly Oriental on Bali and primarily Australian on Lombok.

As to the relationship of Australian vertebrate groups to Wallace's Line, no mammal group comes anywhere near it. There is comparatively little extension of Australian reptile groups toward the Orient; only one frog from the Australian Region extends to Bali, but a significant number of Australian birds do reach the island.

What we can see from all of this is that in all groups that show direction (amphibians, reptiles, birds, and bats) in their extension of range, there is more extension of Oriental groups toward the Australian Region than the reverse.

In summation, while Wallace's Line does serve as a very useful boundary for the study of animal movements and the origins of present-day populations, it is not truly the dividing line between Oriental and Australian faunas. It represents, rather, separation between a nearly full-scale Oriental fauna from a strikingly depauperate fauna, and the beginning of an obvious and broad area of transition. This area of transition extends from Wallace's Line southeastward to a line, just west of New Guinea, known as "Weber's Line," where the islands have a majority of Australian Region animals.

Bali's fauna contains vertebrate animal groups inhabiting an area which is the beginning of a huge and complex transition zone between two of the great zoogeographic regions of the world.

From time to time, certain individuals of a given genus diverge from the primary range of the parent population and move on to relatively distant places. These wanderers often become geographically isolated, and because of differences in habitat they evolve a new set of characteristics. As their segregation from the parent population extends in time, preventing interbreeding with the parent stock, these new characteristics become constant, leading to foundation of a new species. If contact with the parent population is reestablished after this process has run its course, as

occasionally happens, no cross-breeding will result.

The process of geographical isolation is considered to be a primary mechanism for species formation.

Due to the very large and varied presence of the starling family in the Oriental Region, it would seem most logical that the ancestors of the present-day Bali mynah split off from a parent population of starlings somewhere further west in the East Indies or from the mainland of Asia.

Establishment on the relatively small island of Bali, however, may prove to be an Achilles' heel for *Leucopsar rothschildi.* Certain aspects of species dynamics may eventually combine to cause this beautiful songbird's extinction.

Islands such as Bali can become evolutionary traps for certain species due to limited ecological variety, reduction of genetic variability in a small population base, and lack of congeneric competitors. When competitors do arrive, these trapped species are put into a very precarious position, because of their limited ability to adapt to this new threat to their existence.

This fatal lack of adaptability among island species, to which even such an advanced and aggressive family as starlings are subject, can be shown in the extinction of *Aplonis mavornata* from Raiatea Island (one of the Society Islands); *Fregilupus varius* of Reunion Island, extinct since about 1832; and the extinction of *Necropsar leguati* from the islet of Met.

This potential problem for the bird, combined with the negative factors mentioned earlier, generate particular concern for the long-term survival of the Bali mynah.

In fact, the International Union for Conservation of Nature and Natural Resources lists the Bali mynah as an endangered species. This again is primarily because of its very localized habitat, as it is considered to be relatively abundant where it occurs. Whether there has been any decline in numbers of the bird is not known, but there has been some drain on the population as a result of trapping for the cage-bird trade.

Until quite recently, the Bali mynah was not on the list of protected birds in Indonesia. Now, however, it has official protection, so perhaps trapping the species will be curbed.

Other bright spots for the Bali mynah's future are the existence of the nature reserves of Bali-Barat and Sangeh, where some of the bird's natural habitat is thought to remain, and the fact that the mynah enjoys the affection of most Balinese.

Because of all the various negative influences confronting this species, an additional chance for survival might seem to be in captive breeding. As this is now recognized in conservation circles, efforts are being undertaken toward this end.

Ironically, aviculturists have a golden opportunity to make amends for having been the recipients of birds that should have been left to breed in the wild. They have this opportunity because the Bali mynah has been bred, with spotty success, by a number of zoos and aviculturists in Indonesia, Great Britain, the United States, and Switzerland. Until a viable breeding population has been established in captivity, however, the outlook for this species will remain doubtful.

The task ahead, then, is clear. The recognition and acceptance of this conservation responsibility on the part of private aviculturists, however, remains doubtful. The establishment of several generations of aviary-bred stock in any particular non-seed eating species (or, as some aviculturists would inappropriately call them, "softbills") is very infrequent. There are a number of reasons for this, including the fact that most aviculturists have limited aviary space yet try to maintain a large number of species, and the pugnacity of many breeding and parent pairs toward other aviary birds. Also, rearing the young of non-seed eating birds in an aviary requires a lot of effort, time, and expense. Consequently, too many aviculturists devote a minimum of attention and aviary space for the breeding of non-seed eaters, while, on the other hand, maintaining a large variety of such birds for "study" and enjoyment.

On the plus side of the ledger, the Council of the Avicultural Society (Great Britain) has decided to publish an annual census for the Bali mynah in captivity. The hope is that the census will encourage owners of the species to make an effort to maintain and, hopefully, increase its number through breeding. The late W. R. Partridge of Great Britain, a very respected aviculturist and leader in the field, had compiled the first such census of captive Bali mynahs shortly before his recent death. The number he came up with was 171, which might be low due to unrecorded birds in Indonesia and the United States.

Thus, we have Bali and its mynah. Both are enchantingly beautiful, and quite unique. But in order for their beauty to continue, concentrated efforts at conservation are necessary. If we can manage to ensure the survival of this beautiful bird, and its lovely habitat on a romantic island, a certain South Seas mystique will remain for future generations to savor.

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS

"Animal Graveyard" Marks Earth Day at Zoo

Bronx, N.Y. – Row upon row they stood, more than two hundred white "tombstones," on the green grass of Baird Court at the Bronx Zoo. On each tombstone was the name of an animal and the sad legend "EXTINCT." Each tombstone represented a land animal that no longer can be seen on our earth, destroyed forever – by habitat destruction, by hunting and exploitation, and by the introduction of exotic species.

This display of man's inhumanity to his fellow creatures of the Earth was part of a series of special events at the zoo, April 22 to April 26, on the theme "Animal Countdown."

By the 1600s, 21 animals were already extinct, among them the dodo, a bird native to Mauritius Island, and the European lion of Greece. Some 36 more names were added to the list in the 1700s, including 10 species of giant tortoise.

The greatest toll was taken during the last 200 years. In the United States alone, at least 16 land animals were lost, including the great auk, passenger pigeon, Carolina parakeet, and long-eared kit fox.

The story the tombstones told is grim. But it pales beside the thought of the hundreds of animals poised on the brink of extinction today. To call attention to the endangered species, special guided tours were given by zoo curators on Saturday, April 25, and Sunday April 26.

At the end of the display on Baird Court, there were four tombstones that asked the question: NEXT? Of the many endangered animals, those choosen as representatives were: the tiger, an animal that has fascinated mankind through the ages; the blue whale, the largest animal ever to exist on the Earth; and the bald eagle, our national symbol. The remaining tombstone read simply: MAN?

American Alligator Council Meets in Georgia

Waycross, Georgia – A few miles south of this crossroads community on U.S. Highway 1, pinelands give way to the Okefenokee Swamp, home of an estimated 6,000 American alligators. This April, as bull gators bellowed in the swamp, a group of conservationists and scientists met in Waycross to chart a course that would insure survival of the American alligator in the wild.

The meeting, held by the American Alligator Council, took place on April 23 and April 24, even as the Florida State Legislature, then in session, passed two bills that increase the protection given the gator in that State. Both bills make it tougher for the poachers who are the scourge of the wild alligator population. One makes all equipment used by poachers *prima facie* evidence of the intent to poach and provides for arrest on this basis. The other makes poaching gators a felony with a maximum sentence of five years in prison or a $2,000 fine, or both. In addition, all equipment used in poaching is to be confiscated.

Other developments, both legislative and scientific, were discussed at the council meeting. Council member Edward R. Ricciuti, editor of *Animal Kingdom* and curator of publications and public relations of the New York Zoological Society, reported on New York City's new ban on sales of alligator products. The law establishing the ban – it goes into effect July 1 – was hailed by council members who expressed hope that similar laws would be passed by other municipalities.

Scientists from two states reported on tracking alligators by telemetry. Modified versions of transmitters used to track deer were placed on seven alligators at the Rockefeller Refuge in Louisiana last summer, and the gators were followed for up to 150 days. Results of the study showed that females thus monitored ranged an area of about 10 acres around their nest sites.

At the Savannah River plant of the United States Atomic Energy Commission, scientists are studying a population explosion of alligators in a lake whose waters are heated by hot water effluent. Before the lake was impounded in 1958-59, it was the site of a swamp with a population of only a handful of gators. Researchers reported that the lake now supports a population of 300 to 400 alligators, from about eight feet to fourteen feet in length. The absence of smaller gators may be caused by cannibalism on the part of large bulls. Scientists from the ecology laboratory operated by the Savannah River plant and the University of Georgia have begun to track alligators in the lake by means of sonar tags – sound beacons that can be attached to the animals. It is hoped these studies will reveal new facts about the natural history of the alligator.

The Alligator Council spent the second day of its meeting – one of two scheduled for this year – on a field trip in the Okefenokee. More than a dozen alligators, ranging in size from young a foot long to eight-footers were sighted.

Rare Fish on Exhibit at New York Aquarium

Brooklyn, New York – Three specimens of an exceptionally rare fish are now on view at the New York Aquarium. These three live specimens of *Oxycirrhites typus* Bleeker, commonly called the long-nosed hawkfish, make one-third of the total number of nine such fish collected during the past 113 years, since the first one was sighted in 1857 off the coast of Africa. They are the only living specimens of this fish on exhibit in the world.

Observations indicate that the long-nosed hawkfish inhabits waters approximately 35 feet to 300 feet deep. The specimens at the aquarium were collected at a depth of about 100 feet off the coast of Hawaii by Donald Morris, a marine biologist, who is the brother of Robert Morris, curator of the New York Aquarium.

The three fish are each approximately three-and-one-half inches long and show an overall pattern of delicate coral-colored squares. In their tank at the aquarium is a "black-coral" tree, where – as in their native habitat – they are given to resting on their pectoral fins, presumably for protection or concealment.

"Because of their rarity, small size, and the depth at which they were found, these fish were handled with extreme care and brought to the surface very slowly," says Curator Robert Morris, "What the hawkfish normally eats has not been determined but the aquarium's trio are thriving on a diet of two different kinds of live shrimp."

Zoo Guide Program for Members at Bronx Zoo

Bronx, N.Y. – As part of the continuing new services for members, the New York Zoological Society has instituted a zoo guide program which will provide tours of the Bronx Zoo for members in the sustaining category and above. The tours, which will be given during July and August, are by reservation only. One guided tour per membership may be reserved by calling Mrs. Sherry King, Zoo Guide Director, at 933-1500, Ext. 34.

THE WHALE FUND

The Whale Fund was established by the Trustees of the New York Zoological Society in 1969 in accordance with the following resolution:

> RESOLVED: that a fund, to be known as the Whale Fund, be established on the books of the society as a repository for income from whale conservation activities and/or gifts for the conservation of whales.

Contributions to the society for the Whale Fund are being used exclusively to bring public attention to the plight of endangered whales and to finance whale research and related educational and conservation projects. In the hope of augmenting funds for this work, the society and Dr. Roger S. Payne, of the Institute for Research in Animal Behavior, have entered into a contract with Communications Research Machines, Inc., releasing certain of the society's and Dr. Payne's rights in recordings of whale sounds so that a commercial phonograph record "Songs of the Humpback Whale" can be produced and sold by that company. In return, the society will receive a royalty on the sales of the record, consisting of a percentage of its net proceeds. The society is not handling the sales of the record. It can be purchased by writing directly to WHALES, P. O. Box 131, Del Mar, California 92014. The purchase price is $9.95 (plus local sales tax, if any), and checks should be made payable to "CRM Books."

Direct donations to THE WHALE FUND are greatly needed. If you wish to contribute to the fund, checks should be made payable to "N.Y.Z.S. Whale Fund" and mailed to THE WHALE FUND, Bronx Zoo, Bronx, New York 10460. Such contributions are tax-deductible (the purchase price of the record, of course, is not deductible).

Do join us in this significant conservation campaign.

Correction: The photograph of the Spencer's monitor that appeared on page 30 of the April issue of *Animal Kingdom* was taken by H. Millen.

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DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

Picathartes

Picathartes gymnocephalus (right)
and *Picathartes oreas*

"Kup-akok," "Gborhundi," and "Senen-Ntie" are but three of the native names applied to the two species of rare West African birds of the genus *Picathartes.* The native names in literal translation mean "rock-fowl" or "Bird of the Stone," which refers to the rocky habitat where the picathartes are found. Since picathartes are restricted to suitable rocky areas in the tropical forest, their population probably have never been large. Currently hunting and trapping have greatly reduced the already small number of these "rock-fowl" to a point where they are likely to become just another name on the growing list of extinct species.

The white-necked rock-fowl, *Picathartes gymnocephalus,* and the grey-necked rock-fowl, *Picathartes oreas,* are the only members of the genus and subfamily. Today they are considered to be related to the babblers with whom they share many anatomical and behavioral similarities.

When first described, the picathartes were thought to be members of the crow and jay family, Corvidae. Due to the supposed relationship with the crows as well as the bare skin on their heads, the picathartes were known as "bald crows." In 1938 Howe even suggested that picathartes belonged in the starling family. From the fact that picathartes were considered first crows, then starlings, and finally babblers, one can see that taxonomists had a difficult time trying to determine the familial relationship of this odd genus. Because they are so unique, they become of special interest and monetary value. This high value and the relative ease of capture or kill at their nesting sites make the picathartes ready victims of hunters and trappers.

Even though the first picathartes was described in 1825 by Temminck, the rock-fowl were first seen in zoos only a few years ago. In their native habitat in West Africa, very few have been observed by other than natives and trappers. Robert Golding as recently as 1966 observed only a few nests and no birds on his expedition into the Cameroons, where the grey-necked picathartes is known to occur.

Picathartes are very secretive in their dense tropical forest habitat, but in zoos they quickly become very tame and curious. Unfortunately in the past thirty years, these odd creatures with bright-colored bald heads and soft fluffy plumage have been hunted and trapped extensively for museums, zoos, and the bird trade. Because of this hunting the rock-fowl have declined rapidly. The destruction of their forest habitat to allow farming poses another great threat for the future of the picathartes. The Red Data Book of rare and endangered birds, published by the International Union for Conservation of Nature and Natural Resources, lists the status of the rock-fowl as: "Very rare and with little doubt now in danger of extinction . . . undoubtedly declining in numbers."

Both species of picathartes seem to require rocky dry areas where they can build their mud and fiber nests in which the adults roost and raise their young. At the same time, both species seem to prefer wet rocky rivers and small streams along which they feed on amphibians, snails, crustaceans, and insects. If this unique genus is to be saved, any preserve or park established must have both types of habitats to allow nesting and feeding.

Much needs to be done to save the picathartes. Parks and preserves could help, but export restrictions, protection, and law enforcement are urgently needed. The only glimmer of hope in recent years has been the breeding of the white-necked picathartes at the Frankfort Zoo. However, until this becomes commonplace at zoos throughout the world, the outlook for the "rock-fowl" of West Africa is very dim.

DONALD BRUNING

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ABOUT THE COVER

Front: Dr. Rosemary Chapman collects a specimen of the sponge, *Xestospongia muta,* from the Jamaica Reefs for the Osborn Laboratories of Marine Sciences. Dr. Chapman and her husband Paul are able to descend with scuba gear to a depth of 300 feet. Sponges are discussed by Dr. Martin F. Stempien, Jr., in his article on page 2.

Back: Violet-necked cassowary *(Casuarius casuarius aruensis),* a large flightless bird, is native to the Aru Islands, off the southwestern coast of New Guinea. For more on this particular bird, see "Animal Kingdom Reports" on page 28.

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sponges

One of Man's Earliest Gifts from the Sea May Prove Even More Beneficial in the Future

MARTIN F. STEMPIEN, JR.

Today, when most of us hear the word "sponge", we visualize the pastel-colored pieces of cellulose neatly packaged in plastic that we purchase from the supermarket. But, remember the tan-colored shapeless pieces of material which were used, so often, in the past to wash the family automobile? They were real sponges: or, at least, skeletons of real ones. Marine sponges of this and closely related types have been used by man for centuries. They were among the first non-edible marine natural products. Sponges were mentioned in the *Iliad* and the *Odyssey*. Aristotle described them in his treatise on natural history as the skeletons of marine animals with plant-like characteristics.

Sponges have been characterized as animals, plants, plant-like animals, or animal-like plants as a result of two general characteristics of all sponges: a sessile nature, and the absence of any detectable organ system or moving parts.

After the discovery of the microscope, however, cells bearing whip-like processes were observed in sponges. It was not, however, until the 19th century, when the reproductive cycle of several species of sponge was described, that the true animal nature of the sponge was established firmly. Scientists were able to show that a free-swimming ciliated larvae was produced as part of the cycle – an animal, not plant, characteristic.

One of the most important reasons that the animal nature of sponges took so long to define was probably the sponge's simple, and to many scientists, rather uninteresting construction. A sponge cannot be considered a single animal, but rather a colony or "suspension" of two general cell types in an organic matrix called the mesoglea (*meso;* "in the middle"; *glea;* "glue"). The mesoglea is a thick non-cellular material of protein much like dessert gelatine. One type of cell is stationary and carries a flagellum or whip. The other is more like an amoeba, wandering about the interior of the sponge and having no set shape.

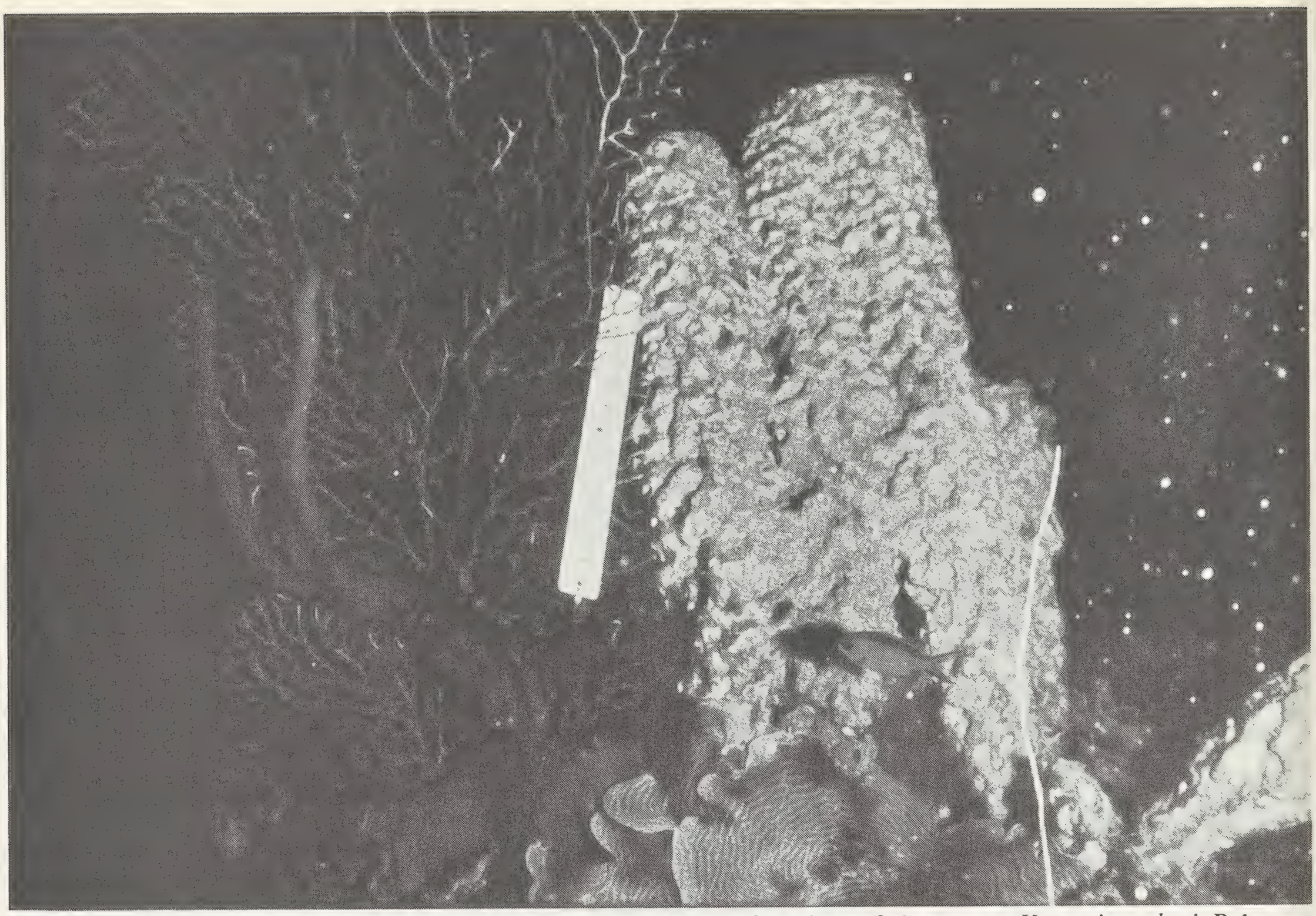
The mesoglea may also be permeated by tiny inorganic structures of various definite shapes – the spicules (*spiculum:* "dart"), and a horny organic material called spongin. These give the animal some rigidity, so that it may have form and attain size and structure. Spongin constitutes the skeleton of the bath sponge, which is obtained commercially by killing and removing the mesoglea and cellular parts of the animal.

The nature and geometry of the spicules and the presence or absence of spongin have been used to divide the sponge phylum into three classes: the *Calcarea,* which have spicules of calcium carbonate; the *Hexactinillida,* which have spicules of silica with a three-axial geometry; and the *Demospongiae,* which have spicules of silica that are without a three-axial geometry or spongin fibers, and sometimes both. This set of criteria is probably the earliest use of strictly biochemical characteristics to define the classification of the main divisions of a phylum of animals.

The flagellated cells are also called choanocytes (*choane;* "funnel"; *cyte:* "cell"), or collar-cells, because of the funnel-like raised collar of organic material which surrounds the single flagellum or whip. Originally this collar was thought to be an impervious sheet of protein, but more recent studies under the electron microscope have shown that it is composed of tiny protein fibers that form a circular seive with holes of about 0.2 microns. The seive filters the current of water produced by the movement of the flagella. Particles caught by this net are transferred into the cell and then to the amoebocytes (*amoeba,* "change"; *cyte,* "cell"), cells responsible for the digestion of food, production of the skeleton and mesoglea, and the reproduction of the animal. Amoebocytes represent a class of cells entirely distinct from the choanocytes. Whether the different types of amoebocytes are really different cells or the same type of cell doing different jobs as yet has not been determined.

Reproduction in sponges is both sexual and asexual. In the former, eggs and sperm are produced in different parts of the animals, and the sperm liberated into the canal system of the sponge. The sperm of an individual sponge has been shown experimentally to be capable of fertilizing its own eggs. However, it is not known whether this is what happens in nature or whether the sperm swims out of the sponge to fertilize the eggs of another individual. In any case, the fertilized eggs develop into ciliated larvae which leave the colony through the canal system. The larvae settle and develop into new sponges.

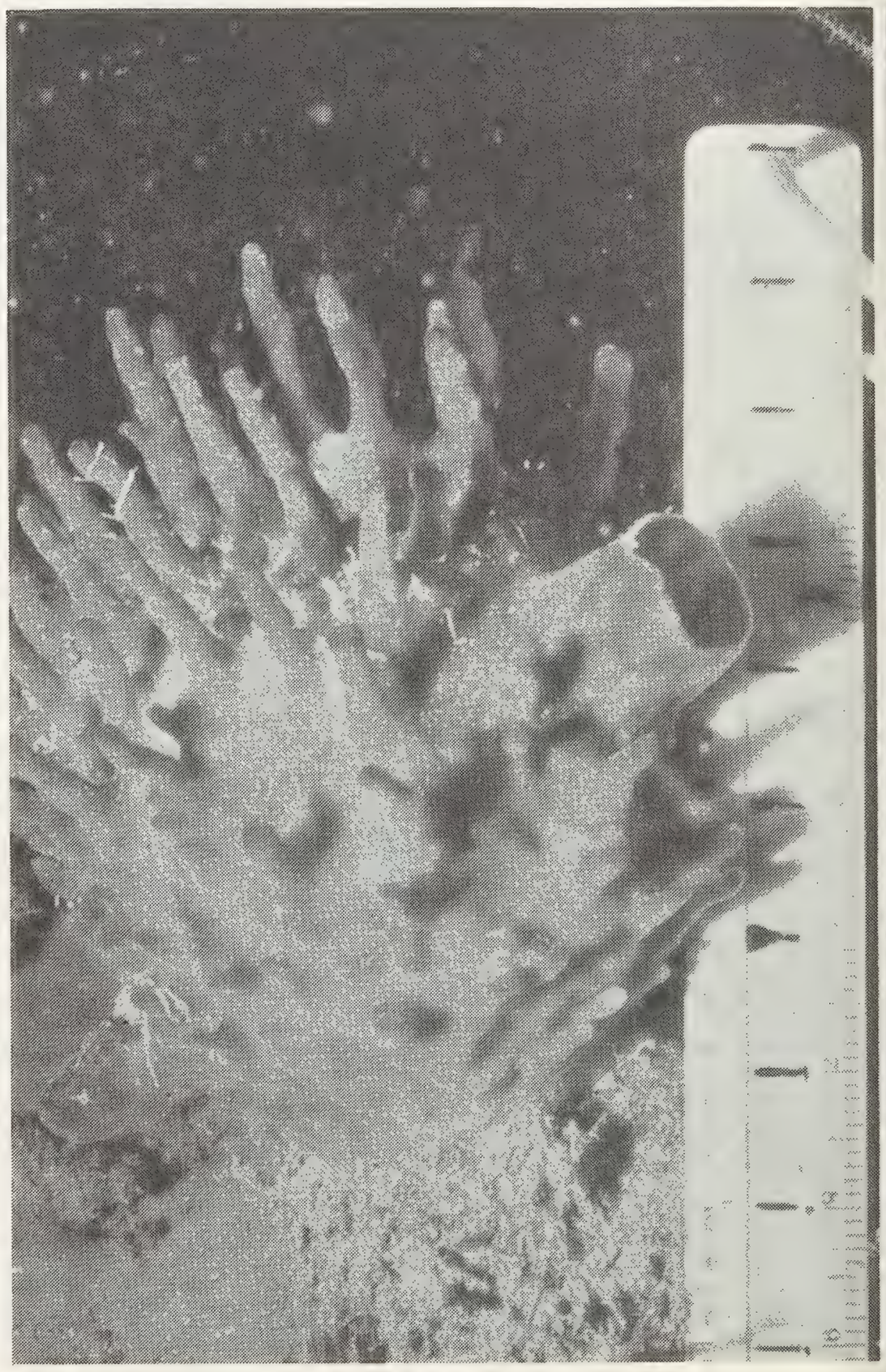
Asexual reproduction takes place in a number of ways. Pieces of the colony that break off may



Sponges vary enormously in shape, size, and color. Above: the soft variety of the sponge *Verongia archeri.* Below: a sponge of the *Rhizochalina* species. Opposite: a sponge of the *Ianthella* species.

settle and develop into a new colony identical with the parent sponge. This process of regeneration is characteristic of many of the lower invertebrates and has been considered as a possible method for the propagation of commercially useful sponges in farms situated along the sea coast. In laboratory experiments, it has been shown that only a few cells of each type are necessary to form a clump that can grow to a complete animal. If a clump is formed of less than about 10 of each type of cell, it eventually falls apart and the cells die. Many sponges also can put out buds that develop into adults attached to the parent, giving the sponge and its offspring the appearance of a many-branched candelabrum.

Another method of asexual reproduction, one which is more characteristic of freshwater sponges than marine forms, is the formation of gemmules. These are small egg-like clusters of cells, not the product of sexual activity, which are deposited by the sponge toward the end of its life cycle, before winter's killing cold can arrive, or before a seasonal pond can completely dry up. The gemmules have an impervious shell which permits them to live through the winter or dry period to hatch when better times arrive. Each gemmule then produces a new sponge colony to start the cycle once again. It



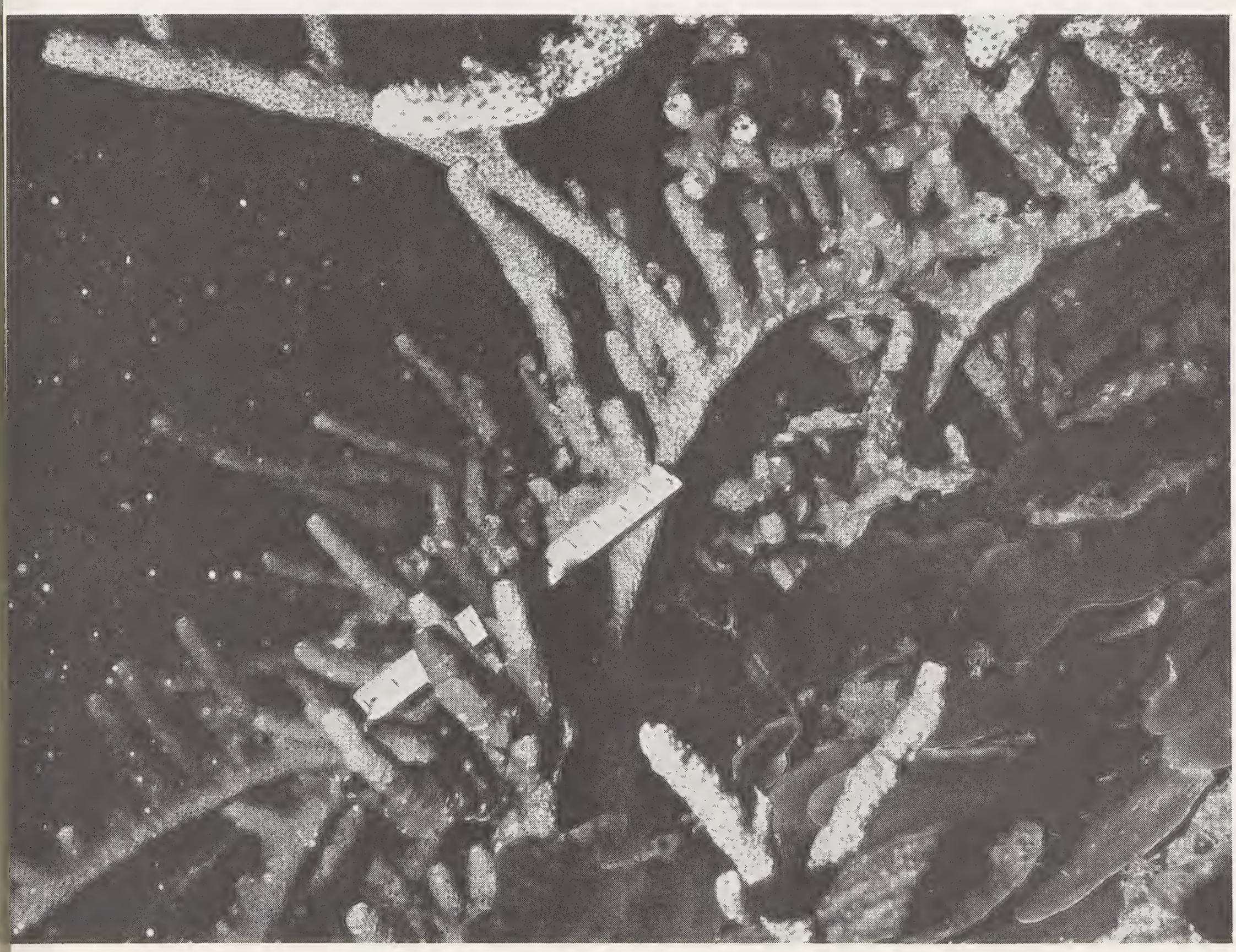
is probable that sponges living under conditions which do not allow a 12-month growing season produce gemmules.

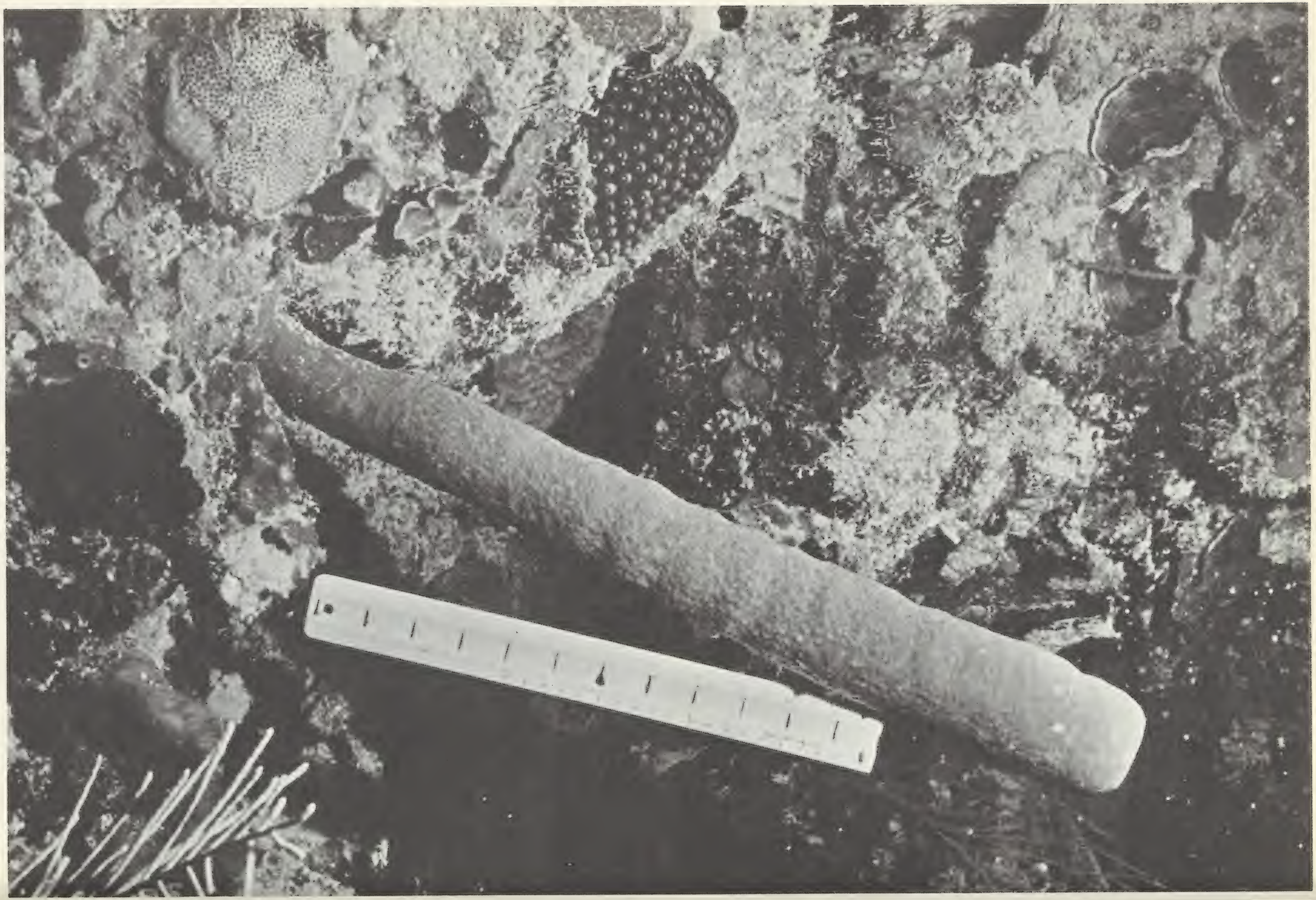
The hundreds of millions of choanocytes beating their flagella within each sponge create a current of water. The water is moved in a particular direction by both the placement of the flagellated cells and the architecture of the sponge.

The simplest type of sponge is in the form of a small vase or cylinder, with many small holes or pores in its side. The flagellated cells line these pores and the water is propelled through the wall and out the top or *osculum* (mouth) of the sponge. All sponges are constructed on modifications of this basic building unit, even though several *oscula* may be evident. In this case, each *osculum* serves the pore system of a section of the whole animal. The volume of water transported by these animals is considerable, and places them along with the bivalve molluscs and the tunicates as the most efficient filter feeders in the ocean. A single sponge of the genus *Callyspongia*, four centimeters in diameter and 10 centimeters long, has been shown to filter about 78 liters of water every 24 hours. By the discharge of water from their *oscula,* tropical sponges living in shallow bays can move the surface water in their area like springs in a pond. One other important result of this stream of water is that wastes produced by the sponge are effectively removed from its area.

In addition to the removal of particles of food from the water stream by the choanocytes, two other methods are used by the sponge to get food. One is the engulfing of food particles from the water stream by the cells which line the larger canals; the other is the absorption of the nutrients dissolved in the water stream.

It has long been known that sea water is, in reality, a solution of amino-acids, carbohydrates, proteins, minerals, vitamins, and other vital food elements. Many animals and plants depend primarily on these materials as a source of food. Scientists do not know to what extent sponges are able to utilize this source of food. Little is known about the basic biochemistry and nutritional requirements of sponges, because of the difficulty of maintaining them under artificial conditions. Freshwater species have been kept for several months, but these represent only a small proportion of the estimated 5,000 species in the phylum.





Experiments are further complicated by the presence of bacteria and algae living in the sponge colony. Whether these organisms are symbiotic, parasitic, or sommensual with the sponge still must be determined.

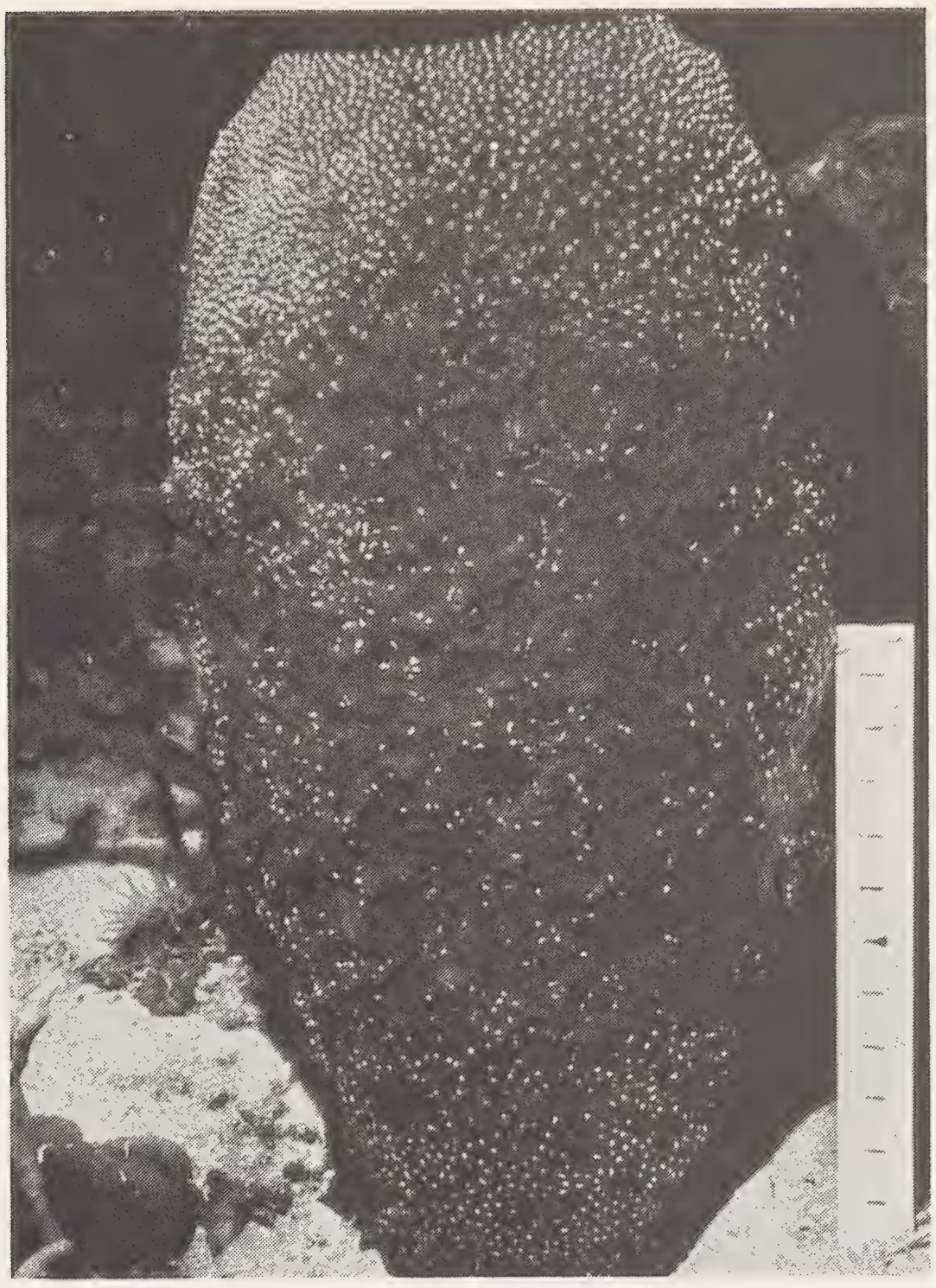
Sponges themselves do not seem to be the prey of many other animals. Only a few species of snails and reef fishes prey on them. Moreover, sponges seem to be well adapted for survival in the oceans, as they are found in all areas from the shallow intertidal zones to the deepest abyss.

They may also constitute a considerable proportion of the biomass in a given area. In arctic waters, for example, the biomass of sponges decreases from 74 percent of the total biomass at depths of 100 to 200 meters to 15 percent at 1,000 to 3,200 meters. While they do not seem to be bothered by most of the micro-organisms found in the sea, a number of rather spectacular epidemics have been noted among the commercial sponges. During the years 1938-39 and again during the years 1947-48, large numbers of these sponges died.

The first epidemic was caused by a fungus-like organism, while the second was of unknown origin. Together these epidemics were responsible for a drop in the commercial sponge production to about 3 percent of its original cash value of several million dollars. Although these epidemics wreaked havoc among the beds of commercial sponges, their effect on other species was not known or recorded. However, because of the relative abundance of other species in areas still devoid of commercial sponges, it has been assumed that the effects were minimal.

It is obvious that sponges have developed a position in ocean ecology equalled by few other animal groups. Since sponges generally are not preyed upon, nor affected by many diseases, scientists have puzzled over how long they live. One may well ask this question, for there is no answer to it. Individual colonies have been under more or less constant observation for 25 years to 30 years, and have remained substantially the same over this period. Some scientists have suggested that in deeper waters, where there is less environmental fluctuation, sponges may live to 100 years, or even longer.

This, and the fact that these organisms have no physical protection from their environment, have led us at the Osborn Laboratories of Marine Sciences to look for biochemical reasons for their success. Do they secrete some sort of poison or substance that warns predatory animals to keep their distance?



Opposite: the hard form of *Verongia archeri* (the soft form is pictured on page 4). Above: the "manjack sponge," *Speciospongia vesparia*. The 12-inch ruler which appears in the photographs provides an indication of size.

During the last eight years, we have been investigating extracts of marine sponges for the presence of compounds which would effect other organisms. For this purpose, we have made several extensive collections of sponges from various areas in the West Indies, from Bermuda, and from local New York waters.

In all, we have collected some 200 species of sponges and have investigated their extracts for the presence of substances which cause a number of physiological activities. These include properties that are antimicrobial, toxic to fish, and effective against developing sea urchin embryos and cancer cells in experimental culture. We also are in the process of testing these extracts for antifungal activity.

Experiments indicate that extracts of marine sponges seem to contain a large number of substances which can profoundly effect the growth and reproduction of other organisms, and that at least 95 percent of all sponges contain one or more of these substances. Whether these biochemicals are used by the sponges to change their environment or for protection is uncertain, but they are being investigated as possible sources of new drugs or models for new drugs which may be of eventual benefit to man.

MENACE TO MARINE LIFE

THE PROBLEM OF OIL SPILLS
BY EDWARD EDELSON

On March 10, 1970, a cluster of Chevron Oil Company oil wells, 10 miles off the shore of Louisiana, began spewing 1,000 gallons of oil a day into the Gulf of Mexico. A month earlier, crude oil, spurting from the undersea wells and floating turgidly on the clear Gulf waters, had ignited at the surface sending a boiling knot of smoke into the sky.

As long as the flames blazed, the oil was consumed. But when the fire was extinguished, a thick river of sticky crude oil, one mile wide and 17 miles long, began floating toward the main seabeds of the Louisiana oyster industry, as desperate efforts were made to scoop the oil up with specially-designed boats or to disperse it with chemicals.

Secretary of the Interior Walter J. Hickel, flying over the oil spill, had a word for it: "disaster." Mr. Hickel had more to say when he found that the wells did not have what federal regulations required – storm chokes, devices that should have been installed 1,000 feet below the surface to shut off the oil automatically when the flow became excessive. "This never should have happened," Mr. Hickel said, as he announced his demand for a grand jury investigation of the spill.

Chevron officials acknowledged that 120 of its 292 offshore wells did not have storm chokes, even though federal inspectors had found the devices in place on earlier occasions. Removing the chokes, experts explained, was one way to increase production from a well.

Other statistics cited by federal officials explained why such an "accident" could happen: the United States Geological Survey had only 31 technicians to inspect 1,711 offshore platforms with a total of 4,689 wells. And even though the federal regulations were clear, they did not contain provisions for penalizing violators. Whatever caused it, the Louisiana incident took its place with some of the biggest oil spills in history.

Most people remember the sinking of the 117,000-ton tanker *Torrey Canyon* off the coast of England in March, 1967, and the blowout of an underwater well in the Santa Barbara Channel of California in January, 1969. Those two incidents attracted world-wide headlines, because of their huge pollution potential and dramatic nature. For many people, they were an introduction to the pollution possibilities of oil slicks. For conservationists, however, both incidents were simply two more battles in a war against pollution of the ocean that now is more than half a century old.

Disastrous as they were, the *Torrey Canyon* and Santa Barbara incidents served one useful purpose: they made more citizens and public officials conscious of pollution by oil slick. As a result, incidents that once went unnoticed are being reported today. In 1968, for example, the Coast Guard collected reports of 714 oil pollution reports, a startling leap from the 211 reported in 1968. But the increase, great as it was, is not believed to reflect anywhere near the real number of spills, which some experts estimate to total closer to 10,000 a year. Even so, most conservationists regard the sudden increase in oil spill reports as a hopeful sign. It means spills are getting public attention.

In just a few weeks in early 1970, conservationists reported battles against oil slicks at Grand Isle in Louisiana, Martha's Vineyard in Massachusetts, Tampa Bay in Florida, Chedabucto Bay in Nova Scotia, and the St. Marks Wildlife Rufuge in Florida.

In every case, living creatures were threatened by a thick coating of oil drifting on the surface of the ocean or a river. The exact effects of oil on the ecology of an ocean or a beach are still not known. Because oil is an organic substance, it is slowly degraded by microbes; it does its damage in the long period before it is removed by the microbes. While the effects of an oil slick on lesser oceanic creatures are uncertain, there is no question of the severe damage that it can do to birds.

When a bird is coated with oil, its feathers become matted together; many ocean-going birds simply sink and drown. The feathers also lose their insulating capability, so that the bird becomes chilled rapidly. To maintain its body temperature, it rapidly metabolizes the fat that is its food

reserve. Weakened and shivering, the bird can go into a state of shock that hastens its death.

Auks and other diving sea birds, including some ducks, are the most vulnerable. "Auks swim low in the water, and they dive to catch their food, so that they become completely covered with oil if they encounter an oil slick," explains Professor R. B. Clark, director of the Dove Marine Laboratory at the University of Newcastle, England. "And – what is worse – there is now evidence that they actually are attracted to oil slicks, because they obviously mistake the calm water for upwellings and fish shoals."

Attempts are being made to count the number of birds killed by oil slicks. The general view of experts is that the best rule is to multiply by 10 the number of dead birds that are found. This rule is based on the fairly well-documented belief that the overwhelming majority of oil-killed birds are not found by man.

The effects of a single incident on a bird population can be disastrous. This was illustrated in the first large-scale oil tanker accident, the sinking of the *Thomas W. Lawson,* with two million gallons of oil aboard, off the Isles of Scilly near Great Britain in 1907. At that time, the puffin population of the Scilly Isles was estimated at 100,000 birds. Today, it is down to 100 pair, and while ornithologists believe other factors were at work, the oil disaster is believed to have played a key role in starting the population decline.

Oil, the experts found, can harm birds more subtly than by simply killing them outright. There is evidence that exposure to oil reduces the reproductive ability of birds – an especially important effect on birds, such as the auk, which lay only a single egg in a year.

"With this low breeding rate," according to Professor Clark, "if half the colony were wiped out – as can easily happen with a large oil escape – it would take more than half a century for the colony to recover its initial strength by natural growth, and that is assuming that there are no further catastrophes in that time."

But catastrophes are not the only worry. Another major source of oil pollution is intentional release of oil, primarily from ships that want to clean their tanks. For a long time, the standard way to clean a tank was simply to pump out whatever oil remained in order to prepare for the next cargo. When there were relatively few tankers at sea, this seemed harmless. But size and arithmetic have caught up with the industry.

A 100,000-ton tanker, medium-sized by today's standards, has 80,000 square meters of steel

surface in contact with its cargo. After the oil is removed, there is some left clinging to the sides, just as some milk is left in an "empty" bottle. Even a thin coating of oil in a tanker this size adds up to about 400 tons. With dozens of tankers at sea, this oil adds up quickly.

"The grand total of all crude oil carried by ocean tankers in 1967 was 700 million tons," says Mr. J. H. Kirby, managing director of Britain's Shell International Marine Ltd. "If all crude tankers entirely washed their tanks to the sea on each ballast voyage, the amount of polluting oil cast upon the oceans would have been 2.8 million tons. Astronomical though this figure is, it is just plain arithmetic."

The petroleum industry has taken steps to reduce this. In 1954 and again in 1962, international meetings were held on the oil pollution problem. After each meeting, stricter regulations on oil release from tankers were adopted. Since the 1962 meetings, tankers which follow these agreements do not release any oil within 100 miles of the shore. And many tankers now use the "load-on-top" system: instead of pumping the oil overboard, they keep it in their tanks until it can be pumped into special facilities ashore.

However, the provisions of the 1954 and 1962

In Santa Barbara, California, straw was used to soak up the oil which drifted ashore after the oil well blowout.

agreements apply only to tankers over 20,000 tons in size. About 20 percent of the industry has not adopted the code. Mr. Kirby estimated that the code reduced the amount of oil pumped overboard in 1967 by 1.66 million tons, with 420,000 tons thrown into the ocean by the tankers that did not follow the code. Another international conference was held at Rome in 1968, which recommended tightening the regulations still further, but nothing has been done about it.

In the United States, efforts to pass tougher anti-spill legislation were blocked for months by a disagreement between the Senate and the House of Representatives. The House bill set a $10-million limit on the liability of a tanker owner for cleaning up a spill, and demanded that the government prove negligence before the money could be collected. The Senate bill put the burden of proof on the tanker owner, and proposed a $14-million bill unless he could prove the spill was not his responsibility.

Each house of Congress passed its own bill – and waited. They might be waiting yet, if the Louisiana spill had not occurred. Spurred by the publicity surrounding the incident, the House of Representatives gave way. In a matter of days, a bill containing most of the provisions of the stiffer Senate provision was passed. The bill was signed by President Richard M. Nixon on April 3.

While the big spills get the attention, small spills can be quite expensive. When a destroyer docked at the Long Beach (California) Naval Shipyard spilled just one barrel of oil overboard, it required a contractor with nine laborers, a boat operator, a truck driver, a crane operator, and a supervisor one-and-one-half days to clean up, at a total cost of $1,300. Larger spills cost proportionately more. The Santa Barbara blowup cost at least $4.5 million in cleanup costs.

The distressing thing is that existing cleanup methods are admitted to be inadequate. During the *Torrey Canyon* disaster, British experts recommended the use of large amounts of detergent to emulsify the oil so that it could be degraded quickly by natural forces. A postmortem study of the disaster disclosed that the detergents, which are highly poisonous, did far more damage to living things than the oil would have done if left alone. Said Sir Solly Zuckerman, Chief Scientific Advisor to the British government: "We now appreciate fully that before any massive action is taken to deal with . . . large releases of oil, ecological considerations need to be carefully weighed, however inconvenient it may be to do so."

Detergents still may be used far at sea, where they will do less damage, Sir Solly said. Inshore, there is still a great deal of uncertainty about what to do. And once the oil reaches a beach, there now are two things to do: leave it alone or use straw to clean it up.

"Nature is the best cleaning agent in the world," said Howard J. Lamp'l, of the Federal Water Pollution Control Administration. "This is especially true of rocky shores and stone beaches. But if anyone tells you that nature removed oil from a sand beach, dig a little deeper – literally. What nature cannot remove, it covers up. Wind-blown sand and the seasonal movement of beaches have a tendency to cover up man's mistakes."

Straw can be used either to sop up exposed oil or to get out oil that is a few inches under the sand. This is done by using a disk harrow to work the straw under the sand, so that it can absorb the oil. After the straw is removed, the beach has to be harrowed or raked to help in getting rid of the remaining oil.

"In an age when we can reach the moon, we should be able to do better than this," says Mr. L. P. Haxby of the Shell Development Company. "The question is really one of whether we are willing to commit the necessary resources of money and scientific skill to get the job done."

After years of neglect, the petroleum industry is starting to work on better oil cleanup methods, on a small scale. The American Petroleum Institute, which represents the multi-billion-dollar oil industry, is spending $1.2 million this year on the problem of oil pollution. Among other projects, the money will pay for the first inclusive report on existing cleanup methods.

The industry is working against a rapidly growing pollution potential. The *Torrey Canyon* was described by the press as a "supertanker," but it is dwarfed by the new tankers being put into use. Already, 75 tankers of more than 200,000 tons are at sea and another 300 are under construction. The Japanese are planning to build tankers of more than 500,000 tons. If one of those should follow the fate of the *Torrey Canyon*, it could cause an unprecedented ecological tragedy.

That is far from a remote possibility. In just

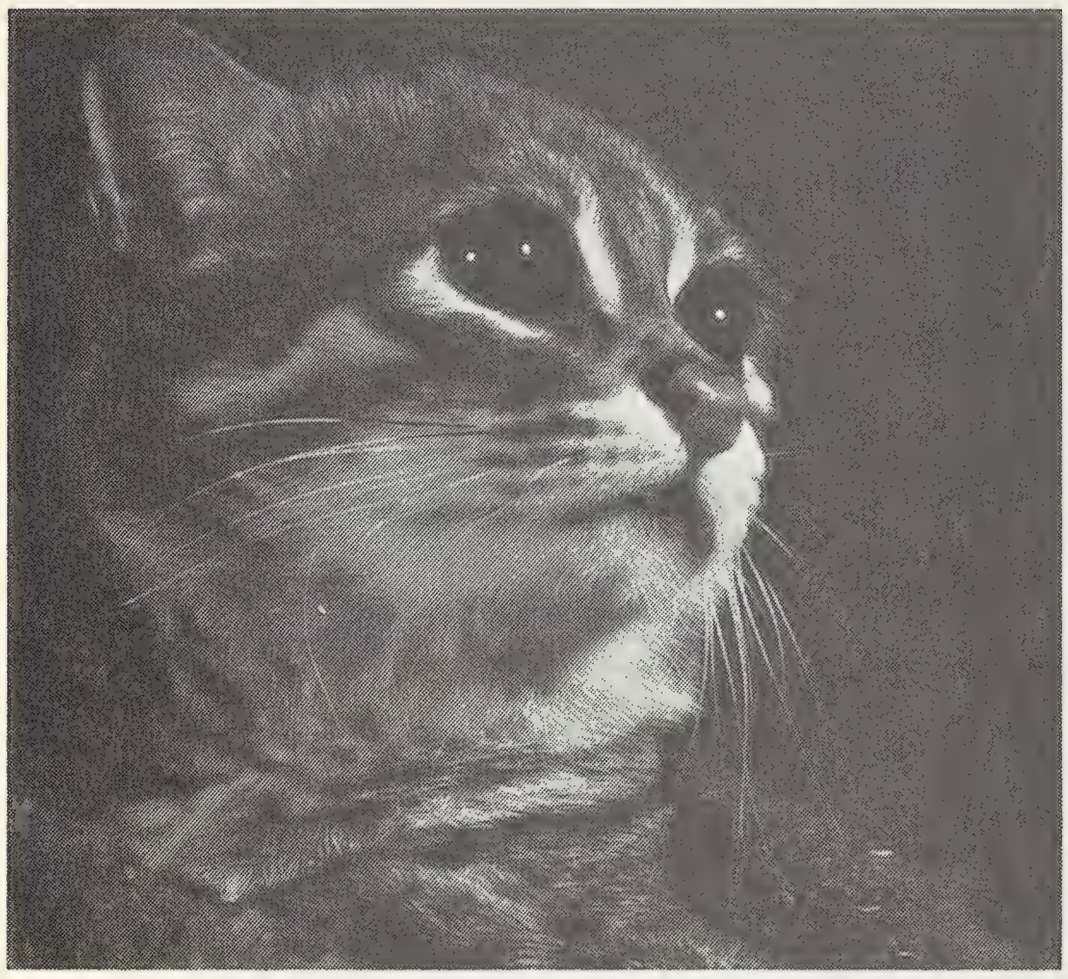
Diving sea birds, such as the gannet (at left, top and bottom) and the loon (at left, center) are particularly vulnerable to the deadly oil slicks. A bird cannot fly or swim when its feathers are matted together, and it loses the layer of air between the feathers and skin that keeps the bird warm and boyant. Death can also result from poisoning, as the bird ingests oil in its attempts to preen.

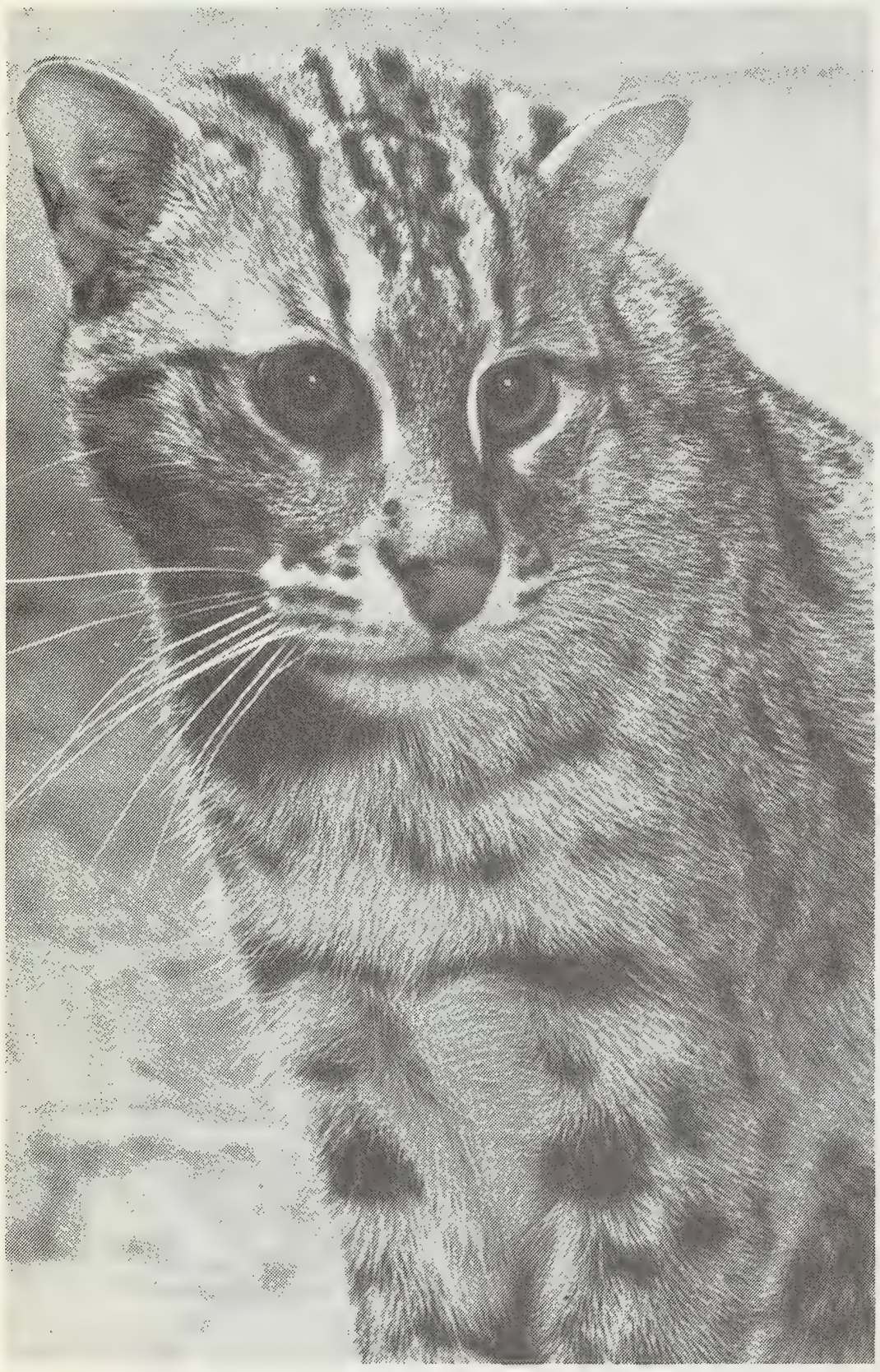
one month at the end of 1969, three supertankers, each over 200,000 tons, exploded at sea. One sank, and the other two managed to reach port. Fortunately, all three tankers were not loaded when the explosions occurred.

The recent oil discoveries on the north shore of Alaska have also aroused fears of large-scale ecological damage. In warm waters, oil slicks are degraded relatively quickly by microbes – although they still can linger for months or even years in some spots. These microbes work much slower in the frigid temperatures of northern Alaska. Many biologists believe that a large oil spill on the North Shore – or anywhere on the long road from the north to market – could produce a slick that would last for decades, perhaps forever.

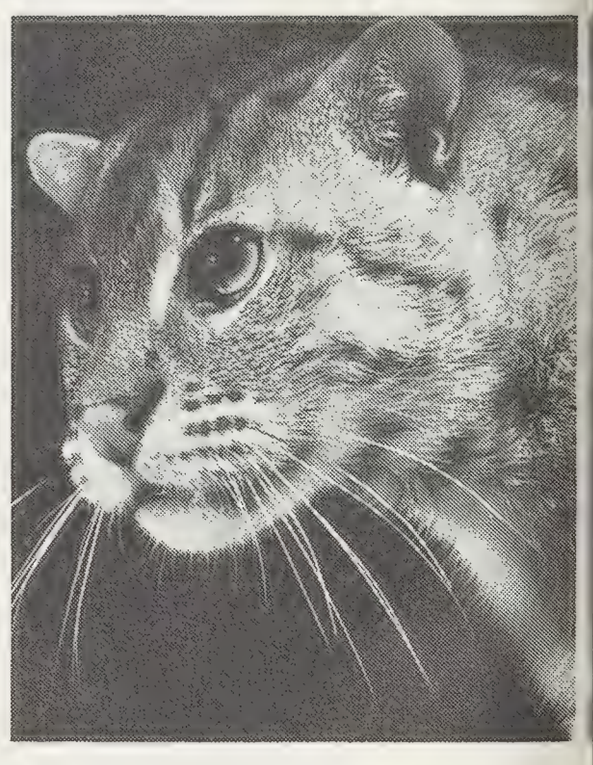
The greatest hope of avoiding such disasters lies in the new aura of concern about oil pollution. A recent conference on oil spills, sponsored by the American Petroleum Institute and the Federal Water Pollution Control Administration, drew 1,100 experts from business and government, three times the anticipated number. Money at last is being spent on effective cleanup methods. Most important, oil spills no longer are the concern of just a handful of conservationists. The public at large is increasingly involved – especially at places like Santa Barbara, where a citizens' group remains vocal and active a year after the residue of the first spill had been cleaned from the beaches. But while the experts study and discuss, the oil still spills into the oceans, lakes, and rivers.

An offshore oil-drilling platform sits amidst the ice in Alaska's Cook Inlet, with the mountains of the Aleutian Range in the distance. An oil slick in these cold waters could last for decades.





AMONG THE MAGNIFICENT CATS...



PHOTOGRAPHS BY WILLIAM MENG

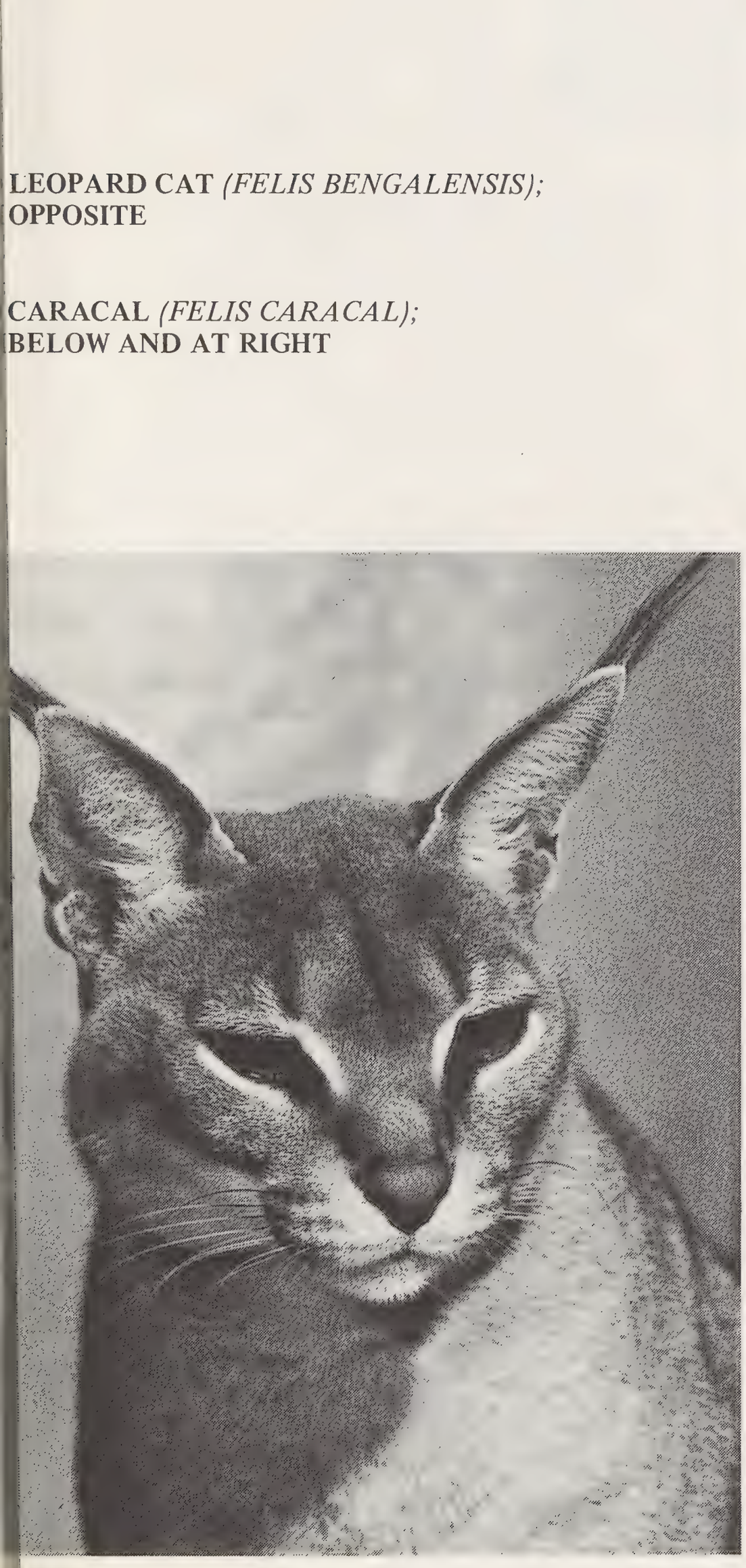
FLAT-HEADED CAT *(FELIS PLANICEPS);*
AT TOP, LEFT AND RIGHT

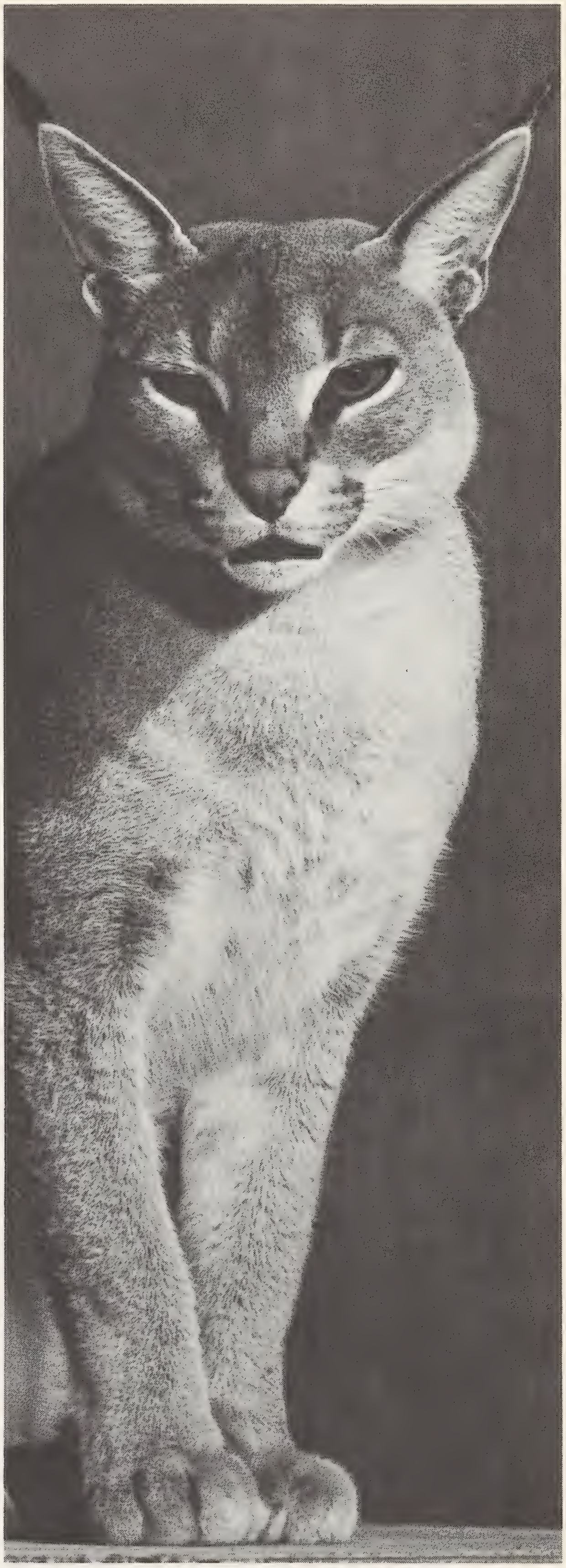
FISHING CAT *(FELIS VIVERRINA);*
AT LEFT AND ABOVE, RIGHT

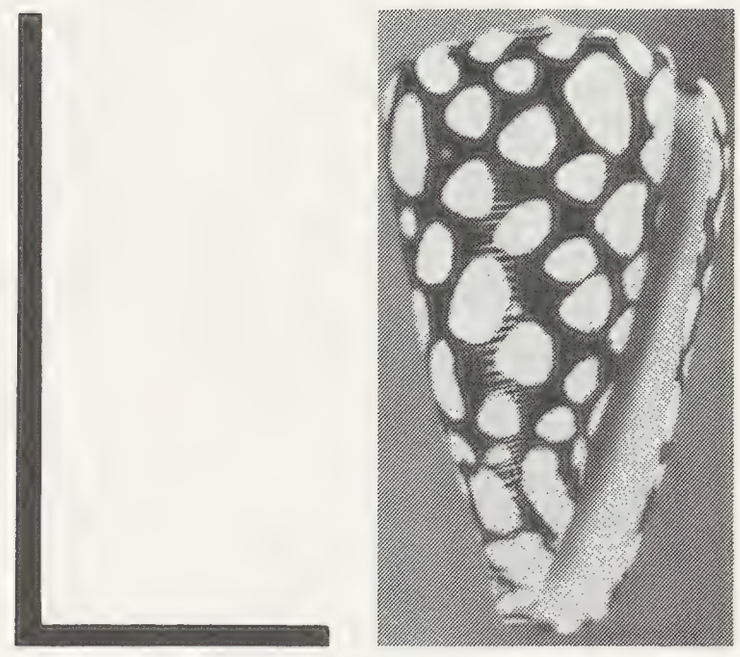
STEPPE CAT *(FELIS LIBYCA CAUDATA);*
OPPOSITE

LEOPARD CAT *(FELIS BENGALENSIS);*
OPPOSITE

CARACAL *(FELIS CARACAL);*
BELOW AND AT RIGHT







LOOK DON'T TOUCH

CONES – PART II

by Fay H. Wolfson

The feeding behavior of all cones studied to date, whether native to coral reef or sheltered coastal bay, follows a general pattern. The sequence that unfolds on a sand-bottom in the littoral zone is as follows:

At low tide, a sandbar exposed by the receding waters presents a tidy picture, well-combed and brushed, punctuated perhaps with holes marking the presence of bivalves, worms, and other marine animals buried below the sand, broken only by inanimate objects – stones, driftwood, shell debris. Approximately one hour before the tide returns, bumps and blips begin to blemish the neatly swept surface. These assume a characteristic shape, by which the practiced tracker is able to identify many of the hidden animals. A wedge of sand (as if made by a cookie-cutter), tilted at the apex, signals that a cone is about to emerge.

The cone may crawl along, drawing its identifiable trail behind it as it moves just beneath the sand. Or it may advance, completely exposed, above the surface. Then the edges of the muscular foot on which it glides are seen below the shell. Whether on, or just beneath, the sand, a slim and graceful tube of rolled flesh projects from the anterior end of the shell. It may be a solid color, or speckled, or the tip may be decorated with one or more bright bands. This is the versatile siphon, which directs a stream of water to the ctenidium (the gill) and osphradium (a chemosensory organ) hidden within the shell. The siphon is also tactile and chemoreceptive. Just below it, two very short projecting stalks bear the tiny eye-spots at their tips. The inconspicuous mouth is central to these.

As the water covers it, the cone glides along, stalking its prey. It has the period – usually six hours – of high tide in which to hunt and to consume its food. This accomplished, it buries again in the sand so that the ensuing low tide, as it moves off the bar, erases all traces of its presence.

A number of factors make it difficult to observe the details of the feeding process in the field. Except when hunting their food, cones are generally immobile. Most of the time – and particularly at low tide – they burrow in sand; shelter under rock, coral, or alga; hide in crevices. They are usually nocturnal; even in a constantly illuminated laboratory, they tend to be more active at night. And many, especially the worm-eating species, hunt, ambush, and feed on their prey beneath the surface of the sand. Hence, much of our knowledge of their behavior must come from laboratory observations.

An aquarium, then, provides the best setting for witnessing the drama of food-getting by *Conus.* Action is initiated by introducing an appropriate prey animal into the water, or even by adding water in which prey organisms have been kept. Almost instantly, the sand erupts, siphons appear above it, each followed by the tip of a foot hauling the shell above the sand. The mouth, no longer inconspicuous, may be slightly open, with the proboscis projecting slightly from within it. The cone advances, exploring its surroundings with the proboscis, now extended two or even three times the length of the siphon, probing the substrate as the siphon samples the water. The chemical stimuli to which the cones are responding are apparently, at least in aquariums, very diffuse; movement is as often away from the prey as toward it and homing on the target is a hit-or-miss affair.

A successful foray is followed by a brief interlude of investigation. In some instances the cone simply opens its mouth and swallows its victim whole. Indeed, the giant leopard cone has never been seen to feed in any other way. But usually the proboscis is run over the victim, the tip prodding in a manner suggesting that the optimal spot for injection is being sought. It is possible that this is the moment of arming.

What comes next occurs so quickly that the eye cannot follow it. The tactics of attack differ with the species of cone and by the type and agility of the prey. In some cases, the dart appears to be thrown free of the proboscis. In others, it seems to be shot but still held by the invisible ligament. More usually, the tip of the proboscis digs into the victim, as if forcibly inserting the dart. A wave of expansion may be seen to flow down the proboscis, as if a liquid were being forced through it. Frequently at the same moment, a puff of viscous white material in the form of a well-blown smoke ring floats off into the water. This may be the source of the myth that the venom is spat.

Cones have been observed to inject more than one dart. In one case, six were loosed in rapid succession. And more than one cone may attack the same victim. *Conus californicus* often indulges in community dinners: nine individuals jockey for position on one worm; more than a dozen dine on a comparatively monstrous moonsnail.

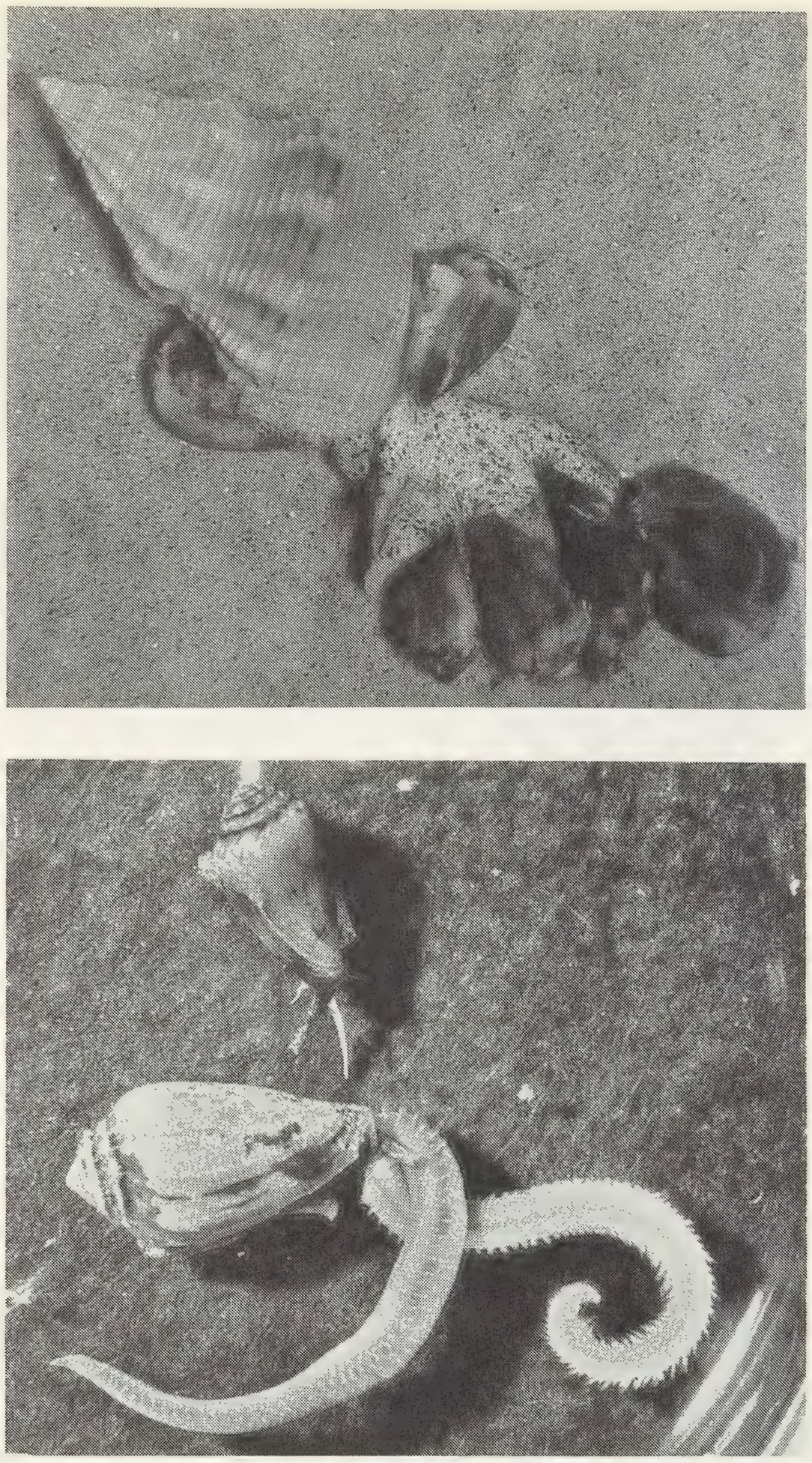
Although reactions of the prey range from successful retreat to instant death, the venom almost invariably acts to inhibit the prey's escape response. The degree of paralysis appears to be largely determined by whether the victim is or is not appropriate food for the cone.

The localized swelling which always appears at the site of the sting may produce secondarily fatal effects. For example, the great fleshy foot of a moonsnail may so enlarge that the snail can neither tuck it back into its shell or move about on it. If, in other words, it should survive the venom, it may be doomed to die of starvation, desiccation, or predation from some other source.

When the victim is sufficiently immobilized and securely impaled, the foot of the cone slides over it, pinning it down; the expanding mouth of the cone protrudes from the shell; the proboscis is drawn, taking victim and dart with it, as far into the mouth as the aperture of the cone shell permits. Then, the mouth, looking for all the world like a pouch being closed by drawstrings, engulfs as much of the prey as possible. But the aperture of the shell of *Conus* is a narrow slit, and its prey is almost invariably too large to be slipped inside. (The prey's bulk may exceed the size of the cone's shell.) The cone's distended mouth, encasing its dinner, must remain outside while the meal is digested. Only as the victim's tissue is broken down does the mouth gradually recede into the shell. The process is rapid, but may yet take several hours, during which time the cone must be extremely vulnerable to predation itself.

Pharmacological research on the venom has been pursued in the United States by Alan Kohn and by Paul R. Saunders and his associates and, in Australia, by Paul Wiener and Robert Endean and his colleagues. To date, the venom of 39 species has been investigated. Extracts have been prepared and tested on crabs, toads, snakes, birds, laboratory mice and rabbits, marine worms, various molluscs, and on preparation of nerve and muscle. The chemical composition of the venom has been described as "a complex of active substances, including protein, quaternary ammonium compounds, and, possible, amines."

But several interesting facts have emerged from these studies. Just as there is no relation between shell size and dart size, there is no absolute



At top: a group of *Conus californicus* feeds on a marine gastrop, *Nassarius fossatus*. Above: one *C. californicus* feeds on a polychaete worm *(Glycera* sp.*)* as another, proboscis extended, approaches to the attack. Opposite: a *C. nux* rights itself in an aquarium.

relation between shell size and potency of the toxin. The extracted venom of drab, innocuous-looking *Conus californicus* is at least comparable to that of *C. geographus,* the champion killer of humans with a documented record of 11 fatalities. It is likely that only the miniscule size of its dart prevents the California cone from piercing human flesh, thus depriving it of a record of human injury.

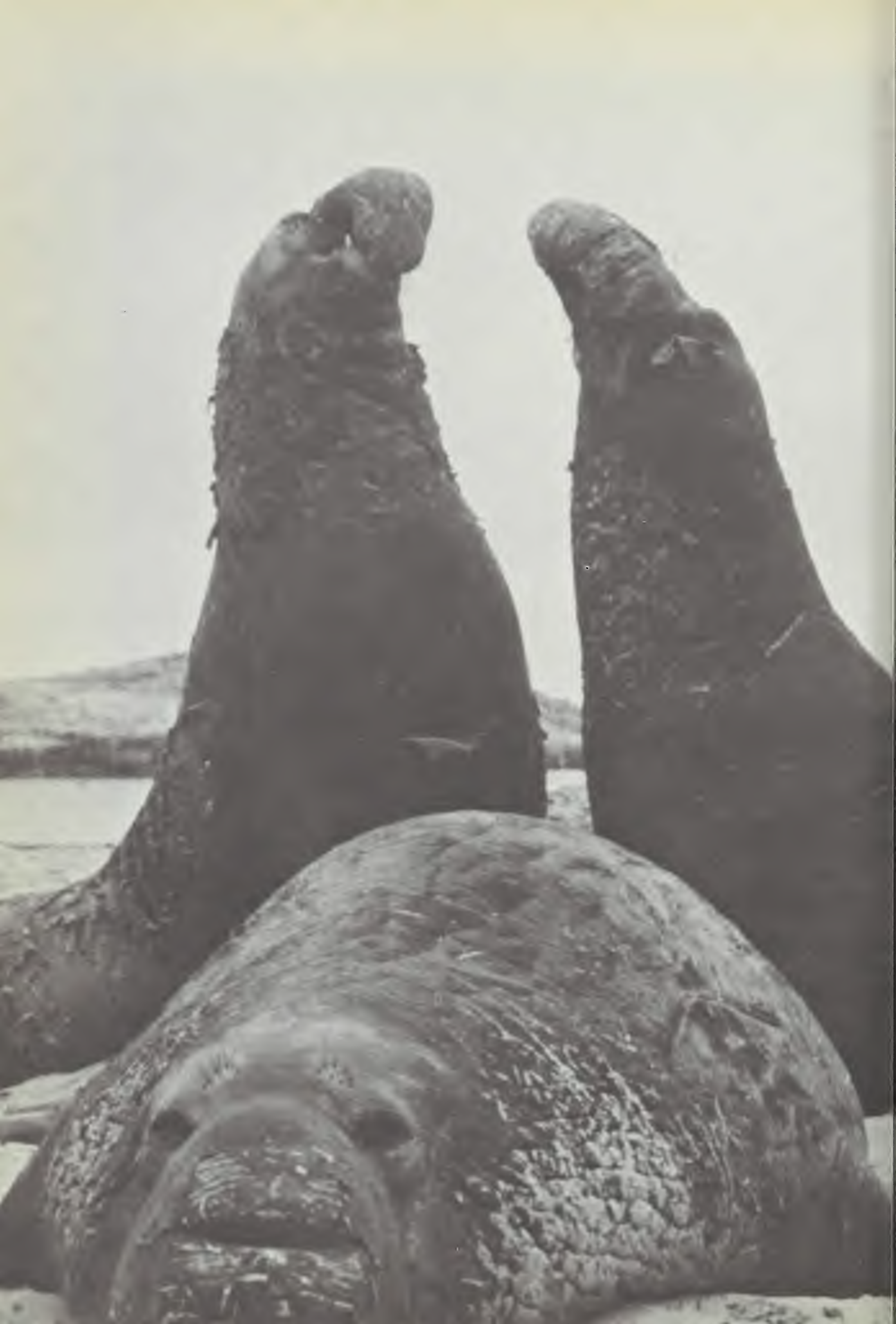
The ratio of dart size to lethality, however does show a correlation in envenomation of humans: large-shelled species with relatively small darts have not been incriminated in any case of severe human injury. This may be due, as suggested of *Conus californicus,* to mechanical limitation.

The effects of cone venom on humans fall into three categories. The least serious reactions have been likened to insect stings, the relatively slight pain dissipating in minutes or hours. The syndrome of severe reactions includes burning sensations, numbness spreading from the site of the sting throughout the body, impaired vision, slurred speech, dizziness, nausea, limb and respiratory paralysis. Recuperating patients complain of extreme weakness and a low threshold of fatigue. Symptoms may endure for several months before the victim fully recovers. In fatal cases, coma may be followed by death within minutes of being stung.

All lethal cases have been ascribed to cardiac or respiratory failure, but the way in which the venom works to bring these about is not yet clear and the single autopsy that has been recorded describes all organs, including heart and lungs, as "quite healthy." The venom's main action may be to interfere with neuromuscular transmission, but there is also evidence that it can act directly on the skeletal musculature without prior neuromuscular blockade. The picture is further complicated by recent findings that the venom of some species is capable of producing both types of reactions.

At our present stage of knowledge, no course or treatment can be prescribed. Fortunately, a number of victims have recovered without medical aid. (The countless stingings which have gone unrecorded must fall into this category.) Natives of the Marianna Islands reputedly have a medicine but, as it must be applied immediately, its usefulness is limited. Physicians who have treated the individual symptoms have had some success. One doctor, recognizing the similarity to snake-bite reaction, treated his patient accordingly and pulled him through. Artificial respiration has revived laboratory animals and is recommended in cases of human injury.

In spite of the continuing research, hope of an antivenin is considered remote. The only course, then, is to stress prevention. A good slogan would be, "Look, don't touch." If it is impossible to resist handling a cone, do so warily. Roll it over. Most cones retract into the shell if disturbed, although *Conus tulipa,* for one, is reported to be aggressive. Then, and preferably with tongs, pick the shell up at the shoulder, never at the sharply pointed end. Even then, look out for the proboscis – alarmingly extensible, it can whip around and behind the apex of the shell with lightning speed, the deadly dart in its tip. We may have learned that cones do not spit their venom, but we can follow no better advice than that of the Yapese to hold them, if hold them we must, well away from us.



SAN MIGUEL

A NATURALIST'S ISLAND
BY DAVID HANCOCK

A mile out from the California shoreline, the sun blazed suddenly through the fog. Its dazzling light shimmered on the surprisingly calm waters of the Santa Barbara Channel. Porpoises played in the wake of the abalone boat on which we were passengers. Shearwaters and Xanthes murrelets flew and dived around our boat. A seal conveniently caught a huge flounder and ate it before our eyes. A massive baleen whale, between 60 and 70 feet long, fed for half-an-hour in wide circles around our boat as we headed westward into the Pacific.

I had previously visited the Santa Barbara area in February 1969 – one month after the disastrous oil leakage at offshore oil rig Platform A. I had walked the once white beaches in boots caked with a sticky mass of sand and oil, and had helped to collect thousands of oil-soaked sea birds that had washed ashore to die. I had seen children stare in awe at pathetically oiled creatures. With the

direct honesty and objective clarity of youth, they asked, "Why?"

It was now mid-July, and this time our objective at Santa Barbara was to observe and to photograph the vast numbers of seals and sea lions that live on the island of San Miguel, the westernmost of the Channel Island. This island is located at the convergence of the cold Pacific waters of the north and the warmer waters of the south – a rich mixing pot that has attracted more species of pinnipeds, seals and sea lions, than any other island in the world.

Five hours and 38 miles out from Santa Barbara, my wife Lyn and I waved farewell to the boat that had brought us to San Miguel. Although the sea was glassy calm, the ocean swells crashed mercilessly against the reefs and beaches. Cautiously, we guided our rubber boat through the myriad of offshore reefs towards a partially protected bay.

The only residents of the islands, Bob and Marty De Long had seen us and were running over the sand dunes toward the bay. I hoped Bob would help us get safely through the surf line.

For some minutes we sat in the calm waters studying the sequences of the waves as they crashed onto the beach. I planned to steer the boat into shore just behind a wave and, at the last moment, pull the motor from the water. Lyn was ready to jump overboard and run up the beach with the long bow line. Hopefully, Bob would be there to grab one side of the boat and I the other. Then before the next six-foot wave could crash down upon us, we would be running up the beach with the boat.

All worked according to plan except that Lyn, not realizing the boat had such a fast forward speed, hit the beach head first. Her legs folded up under her and she landed face-down in the retreating surf. Instantly, Bob was helping my embarrassed and wet wife to her feet and, at the same time, pulling furiously to get the boat up the beach.

Next day the early morning fog lifted the curtain on the rich drama of life that San Miguel had to offer. Camera-clad, we set off to explore the island.

The island of San Miguel is home for many animals, among them tussling bull elephant seals (overleaf) and "squinty-eyed" small foxes (at left, top and center). However, the island is not too far from modern civilization, as an oil-covered sea lion pup attests (at left).

Bob, a zoologist with the U. S. Fish and Wildlife Service, was already at his telescope in the blind above the fur seal colony. The story of the fur seal on San Miguel is indeed a modern day biological oddity. The valuable pelts of the northern fur seal and the sea otter brought the first explorers and exploiters to the western coast of North America. These great herds of fur seals were slaughtered so rapidly that it was never determined if this species bred anywhere but on the islands of the Bering Sea.

their flippers to toss clouds of sand over their bodies, as protection against heat and flies. As the sand heated, brigades of seals would flop down to the splash zone where the surf gave them relief.

As well as making notes of the fur seals' activities on the beach, Bob had been keeping a careful record of the temperature of the water and the sand. He had buried thermometers on the beach with wires leading up to the shack.

Walking across the dunes, covered with blossoms and shells, was very enjoyable. Before San

The elephant seal colony allowed the Hancocks to walk easily among them, so that taking a photograph of this bull elephant seal with its large proboscis posed no problem.

One can then appreciate the surprise among biologists when, four years ago, a lone bull and his harem of a dozen females and their pups were found hauled out on the hot white sands of San Miguel, so unlike the cold wind-ravaged rocks of the Bering Sea, 2400 miles to the north.

Bob had come to the island for six months to initiate a long-term study that was planned to follow the expansion of these pioneering animals. The first pups were observed born here in the summer of 1968. At that time two tagged females were caught. Interestingly, one of the females had been tagged six years earlier in Alaska. The other was also tagged as a pup, but on the rookery of the Comandorsky Islands.

The little colony of over 100 fur seals had their rookery about a hundred yards below Bob's tiny observation shack at Adams Cove on the western end of the island, a wide expanse of sandy beach shared by much larger colonies of California sea lions and northern elephant seals.

The day was hot and everywhere the seals used

Miguel was taken over by the United States Navy for missile gunnery practice, ranchers had run over the island with sheep and cattle. The original brush vegetation had been overbrowsed and killed. Now the sandy island is being eroded by constant winds. In place of the trees, and helping to stabilize the island, are delicate yellow, blue, red, and white flowers, mostly of the ice plant family.

On the wind-swept, sandy stretches of San Miguel, we found many intriguing objects at our feet – Indian artifacts and fossils. Once buried by time, these are now exposed with each sand storm, offering bonanza to the archeologist who can find everything from arrowheads to large bowls. We found a large mixing bowl which measured a foot across.

Almost the entire surface of the island is covered with the bleached white shells of a land snail which once foraged on the lush vegetation that has now long since eroded away. The shells form beautiful intricate patterns upon the sand.

Standing like white ghosts of the vegetation

The female California sea lion (at right) acts as a nurse to a group of pups playing on the rocks of a bay that is one of the island's breeding grounds for the species.

that once covered the islands are caliches. These calcium deposits, through some little-understood process, have formed into the shapes of plants that once lived there.

The most mangy and emaciated-looking foxes imaginable were encountered daily as they hunted the sand dunes. The foxes of San Miguel are a diminutive form of gray fox. Their natural diet on San Miguel seemed to be white-footed mice and seeds. They appeared half-blind, squinting out of narrow eyes like slits, yet this probably is an adaptation to the constantly blowing sand and the hot sun.

To entice the foxes nearer for closeup photography, we threw them bacon rinds. After eating a single rind, each fox would rest for 15 minutes before tackling a second one, as if its small stomach could only digest one at a time. Their courage and my stupidity both rapidly increased until the inevitable happened – my finger was mistaken for the bacon rind.

I have studied the bald eagle for many years, and was most intrigued to find a couple of abandoned bald eagle nests on San Miguel. The one closest to our camp was a mass of twigs and sticks 14 feet deep, overflowing from a wide crevice between two big boulders. Unfortunately no bald eagles had been known to nest there for more than 20 years. In the center of the nest was a bleached unfurred tennis ball – I wonder how many unproductive hours, day, or weeks it had been incubated.

Although the fur seal colony was photographed through telescopic lenses from positions well hidden in the sand dunes, there was no need to fear disrupting the elephant seal colony. About 7,000 three-ton elephant seals lay sprawled on top of each other in one black heaving mass on the sand spit. Our attention was drawn not only to the sheer massive bulk of the elephant seal's great body, but also to the creature's grotesque and inflatable proboscis.

Now and then, two bulls would raise their tremendous bulks and face each other as if ready for combat. Usually, each would life up its proboscis and wave it up and down several times, simultaneously emitting a deep-throated bass honking.

Some males were very old; their skin was pink and splotched, and bore scars from many a battle while defending their territories in the breeding season. The great liquid dark brown eyes of the females and young looked cowlike.

Some of the huge seals wallowed like hippos and blew irridiscent bubbles in the green, viscous muck of the tide pools. Others splashed about in the more aesthetic surroundings of the surf. Occasionally, an elephant seal would leave the tightly-packed colony and lumber off toward the sea. Then one needed to be able to dodge quickly, as once on the move, an elephant seal does not seem to change direction very easily. If anything is in its way, then it is very likely the seal will go right over or through the obstruction.

The oil-slicked bays at the northwest end of San Miguel are the breeding grounds of the

California sea lion. Fortunately only three small bays, perhaps not encompassing more than a half mile of beach, were inundated by oil from the Santa Barbara spill. Several groups of blackened pups huddled on the oiled beaches amongst the driftwood and remains of past shipwrecks. We moved down to the water's edge in a comparatively clean area, where pups were huddled in the hundreds on the rocks, where the mothers were swimming and resting in the adjacent waters, and where the big bulls were lolling about, necks outstretched towards the sky and eyes closed in the sun.

As we carefully approached, the pups paid little attention; the females moved further away; the big bulls merely kept one eye open and directed towards us. One majestic old bull, deeply gashed and cut by many a battle, made such a royal subject for photography that Lyn sat for a long time taking his portrait from a distance. Then she approached within a few feet of his great bulk until her camera was resting on a shelf of rock, separating them by 15 feet. I was amazed at how her close presence had not affected him. To get better support for the camera, she placed one foot on the other side of the rock. That did it. The sea lion charged with a deep growl, his eyes opened fully and thick bull neck stretched out. The bull was merely defending his territory; while Lyn's feet stayed on her side of the rock boundary between them, all was well, but as soon as she invaded his territory, he lunged.

Lyn and I left this grand creature alone as sole master of his territory and returned to camp for a dinner of abalone and mussels.

Of the eight islands in the Santa Barbara Channel, we found San Miguel the most fascinating – in its biology and in its history. Prehistorically, mammoths, foxes, and mice roamed its forests. Much later the Canalino Indians came in their plank canoes. For many centuries they lived in and subsequently abandoned some 50 villages before the historic period began with Juan Cabrillo's visit in 1542. This Portuguese navigator and explorer died on the island the following year, and a small memorial to him stands at one end of the island.

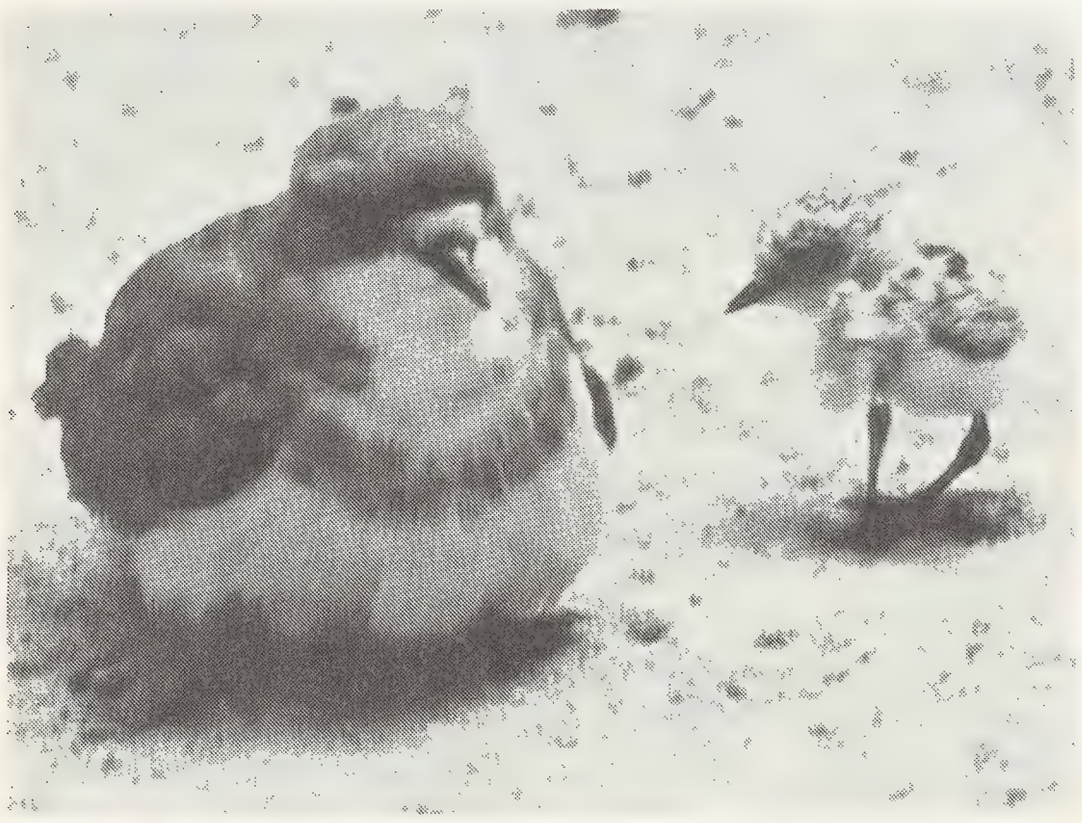
We hope that this little island will withstand the ravages of man as it has the onslaught of wind and water over the last million years.

While the animals of San Miguel were mostly cooperative as subjects for the Hancock's photography, this elephant seal pup in a threatening posture evidently had decided that enough was enough.

animal kingdom

NEWS OF ZOOS, AQUARIUMS, AND CONSERVATION

REPORTS



Under the watchful eye of its parent, the first puna plover chick to be bred in captivity explores its habitat in the shore scene of the Bronx Zoo's Aquatic Birds Building.

Puna Plovers Breed in Captivity

The most recent in a long list of successful breedings at the Bronx Zoo's Aquatic Birds Building was accomplished by a pair of puna plovers *(Charadrius alticola),* small chunky chestnut-capped birds native to high arid plains in the Andes mountains of South America. A small flock of these birds were obtained from the well-known collector, Charles Cordier, in 1966 and have been exhibited in the shore scene since their arrival here. On May 22, 1970, a puna plover was discovered sitting upon three eggs, resting in a simple scrape, at the rear of the exhibit. The chicks hatched on June 16, but only one specimen survived after a few days. This bird was nearly full grown by mid-July. Although the puna plover is a familiar bird in the Andes of Peru, Bolivia, Argentina, and Chile, its nest and eggs were only discovered in the wild in 1965. The breeding at the Aquatic Birds Building probably represents the first for this species in captivity.

Bridges Protect East African Wildlife

Two new bridges over the Mara River in East Africa have made it possible for game rangers from two nations to protect wildlife herds in two formerly unpatrolled areas.

The bridges – one in Tanzania and the other farther upstream in Kenya – were financed by the New York Zoological Society through the African Wildlife Fund. Cost of the dual bridge construction project was $30,000.

The bridge in Tanzania provides a road link to a tract called the Lamai Wedge, adjacent to Serengeti National Park. Animals from the park frequently cross the river to graze in the Lamai Wedge. For some time game authorities have been worried by poaching in the area. With the building of the bridge, the Wedge area could be integrated into the national park and game herds there protected.

The Lamai Wedge is bounded on the north by another game area, the Mara Triangle, which is in Kenya. The upstream bridge makes the Triangle area accessible to Kenyan wildlife patrols. The Mara Triangle, while not in a national park, is in the Mara Masai Game Reserve and has spectacular wildlife populations. Living in the Triangle are zebra, gnu, buffalo, giraffe, and many other hooved animals, including one of the few remaining herds of roan antelope. The Triangle also has a representative population of predators.

Bronx Zoo Loses an Old Friend

Herby, the Bronx Zoo's famous violet-necked cassowary (pictured on the back cover), came to the park in May of 1935 and died here on July 9, 1970. The strange knobby casques that cassowaries have on the tops of their heads earned this bird its nickname and a somewhat dubious honor for the zoo's veteran curator of Education Herbert Knobloch; the descriptive quality of Mr. Knobloch's surname was too great to be overlooked. For 35 years this great bird was a major attraction for zoo visitors. At the same time Herby enjoyed the reputation of being the bane of all junior keepers learning how to take care of the large flightless birds, housed in the Ostrich House. Huge size, a powerful kick, and an uncertain disposition assured Herby of a solitary, celibate existence. As it turned out, chaste might really be the better adjective, for the long-held suspicion that Herby was, in fact, a female was borne out by post mortem examination. Herby was the oldest bird in the zoo's collection.

New Guide Book for Aquarium

From *Abudefduf saxatilis* (sergeant major) to *Zebrasoma flavescens* (tang), a guide to representative fishes, aquatic invertebrates, reptiles, birds, and mammals can be found in *The New York Aquarium Book of the Water World* by William Bridges. Curator of Publications Emeritus of the New York Zoological Society, Mr. Bridges has written a companion volume to *The Bronx Zoo Book of Wild Animals.* Published by the American Heritage Press, *Water World* contains 287 pages with over 60 pages of color photographs. Although not available by mail order, it can be obtained at the gift shop at the New York Aquarium or at the Safari Shop at the Bronx Zoo for $2.00 plus tax.

Cub Scout Day at the Bronx Zoo

The New York Zoological Society designated Saturday, August 8, as Cub Scout Day at the Bronx Zoo in recognition of scouting's conservation programs. More than a thousand Cub Scouts, parents, and leaders visited the zoo and took the special tours on endangered animals provided for the occasion.

"Cub Scout training instills in young Americans at an early age a reverence for nature and wildlife, and the New York Zoological Society wanted to acknowledge this valuable program," said General Director William G. Conway. "The society is hopeful that it can help encourage wider adoption of conservation education and practices among the young. In view of the environmental problems facing mankind, the efforts of the generation represented by Cub Scouts may play a critical role in determining the kind of world future generations will live in," he said.

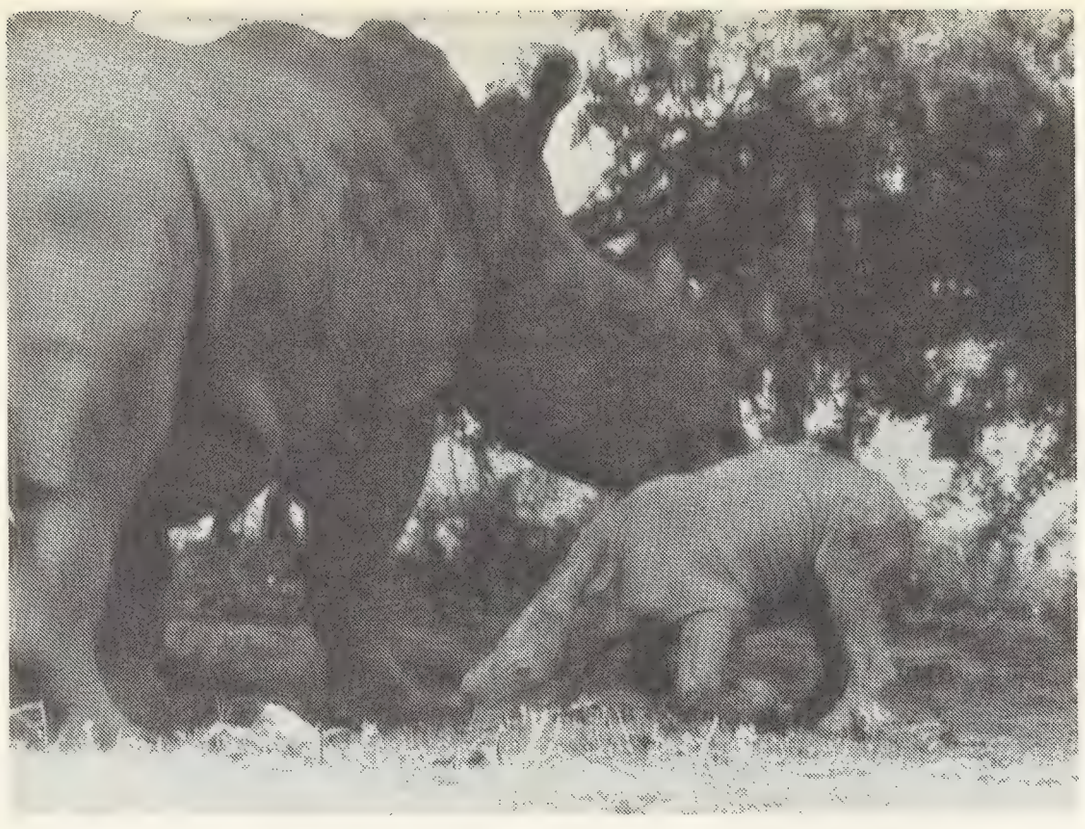
The New York Zoological Society hopes to sponsor a similar day for Brownies at the New York Aquarium in the future.

Have You Tasted the Tamarasalata?

While Jeff and Garret Warner sang sea chanties, the Coney Island Chamber of Commerce dined on conch fritters and crab mousse with dill sauce at the New York Aquarium on July 23. The dinner, hosted by the aquarium, was all seafood (naturally), except for beverages, a vegetable, salad, and rolls. Even the dessert – seaweed blancmange – came from the sea. Although the menu contained some exotic dishes, all items served are available at most fish markets, food markets, and specialty stores. The menu was as follows:

Tasters' Table: sable fish, egg stuffed with cod roe, conch fritters, saury, tamarasalata, lizardfish, gefilte fish, sea urchin roe, smoked eel. *Seafood Smorgasbord:* trout with mustard, crab mousse with dill sauce, herring in sour cream, smoked clams and oysters, poached salmon, caviar. *Entree:* grilled Greenland turbot with lemon butter, corn on the cob. *Dessert:* seaweed blancmange. Beverages, salad, rolls. Seconds, anyone?

This youngster (at left) is the first ostrich to hatch at the Bronx Zoo. When hatched July 28, the chick weighed less than two pounds and was less than one-foot tall. The chick's parents, on exhibit in the African Veldt, are seven feet tall and weigh about 300 pounds.



Pretoria, South Africa – The first white rhino to be sired and born in a zoo is pictured above attempting to get to his feet when approximately one hour old. The male calf was born on October 23, 1969, at the National Zoological Gardens of South Africa in Pretoria. He was, in fact, a birthday present; he was born, after a gestation period of approximately 15 months, on the day the seventieth anniversary of the Pretoria zoo was celebrated, and he was named Seventy in honor of the occasion.

Bird Paintings of Arthur Singer at Bronx Zoo Gallery

This summer Arthur Singer's birds returned to the Bronx Zoo. Mr. Singer, a renowned ornithological artist, has over the years used as models for many of his paintings the birds in the zoo's exhibits. Their portraits will hang in the Bronx Zoo Gallery, located in the Heads and Horns Museum Building on Baird Court, until the end of October. On display are 40 oils, temperas, and acrylics, of such subjects as a life-size harpy eagle and a 5-foot shore scene with a peregrine falcon.

Mr. Singer's visits to the Bronx Zoo began when he was three years old, continued through the years of his formal art training at Cooper Union, and increased in frequency when he devoted his full time to wildlife painting. He was awarded Cooper Union's Alumni Associatian's first St. Gaudens Medal for professional achievement, and he received another citation from the school in 1967.

Sports Illustrated gave Mr. Singer his first professional assignment in 1955, for a feature, "Bird Watcher's Guide." His first major work was a four-year collaboration with Oliver Austin to produce *Birds of the World,* a monumental volume in which Mr. Singer illustrated 750 species of birds of 155 families. His other books include *Birds of North America: A Guide to Field Identification, Guide to Zoo Animals, The Hamlyn Guide to Birds of Britain and Europe, British and European Birds in Colour,* and two books now in preparation.

INVITATION TO JOIN THE TRAINING PROGRAM FOR VOLUNTEER GUIDES

The great majority of New Yorkers will never again see any wild animals (with the exception of gulls, rats, roaches, and introduced pigeons and starlings) except in zoos and aquariums. Yet the votes and interest of these people will help determine the future of wildlands and parks, of diminishing wild creatures and natural beauty. Zoos have the potential for becoming not only the liveliest but also the most effective of all city institutions in the compelling task of environmental education.

Zoos need the help of trained volunteers in order to fulfill this potential. A course to prepare volunteers to participate in the zoo's educational efforts by acting as guides and discussion leaders for groups of school children at the Bronx Zoo and Central Park Zoo will be offered by the New York Zoological Society for the first time this fall. The course will stress the role of zoos in conservation and the protection of endangered species, and it will include the history of the zoo, health problems, and animal behavior at the zoo, and introductions to the three major groups of animals exhibited: mammals, birds, and reptiles. Practical experience will be provided by tours of the World of Darkness, the Aquatic Birds Building, the Children's Zoo, and the Central Park Zoo. After completion of their training, volunteers will be expected to devote a regular portion of their time to guiding groups of children.

If you are interested in sharing in the challenges and rewards of the society's educational programs, please return the application form (enclosed with this issue of *Animal Kingdom)* as soon as possible. Space in the initial class is limited, and it may not be possible to include all applicants.

For additional application forms and information, please contact Dr. Katherine Ralls, Assistant Curator, Education Department, New York Zoological Society, Bronx, New York 10460.

THE bookshelf

THE CONSERVATION FRAUD. *By Charles Zuhorst. 164 pp. Cowles Book Company, New York, 1970. $4.95.*

ECOTACTICS. *Edited by John G. Mitchell. 288 pp. Pocket Books, New York, 1970. $.95.*

THE ENVIRONMENTAL HANDBOOK. *Edited by Garrett De Bell. 365 pp. Ballantine Books, New York, 1970. $.95.*

CONSERVATION: NOW OR NEVER. *By Nicholas Roosevelt. 238 pp. Dodd, Mead & Company, New York, 1970. $5.95.*

THE ENVIRONMENTAL REVOLUTION. *By Max Nicholson. 366 pp., 69 photographs. McGraw-Hall Book Company, New York, 1970. $10.00.*

A DIFFERENT KIND OF COUNTRY. *By Raymond F. Dasmann. 276 pp. Illustrated with photographs. Collier Books, New York, 1970. $1.95.*

SINCE SILENT SPRING. *By Frank Graham, Jr. 333 pp. Houghton Mifflin Company, Boston, 1970. $6.95.*

AMERICA'S CHANGING ENVIRONMENT. *Edited by Roger Revelle and Hans S. Landsberg. 314 pp. Houghton Mifflin Company, Boston, 1970. $6.95.*

CHALLENGE FOR SURVIVAL. *Edited by Pierre Dansereau. 235 pp. Columbia University Press, New York, 1970. $7.95.*

POLITICS AND ENVIRONMENT. *Edited by Walt Anderson. 362 pp. Goodyear Publishing Company, Pacific Palisades, California, 1970. $7.95 cloth, $4.60 paper.*

This is open season for writers of ecology books. Earth Day and the publicity it gathered for the cause of conservation have roused publishers to a frantic effort to get books of all descriptions on the market. The current lot of books is decidedly a mixed bag, ranging from the admirable to the improbable.

To start from the bottom, there is *The Conservation Fraud*, by Charles Zuhorst. The author appears to have a genuine feeling both for the outdoors and for the conservation. However, something – it's never quite clear what – has made him resentful of "special interest groups" which, he says, are hurting the cause. His arguments are contradictory enough to prevent his book from having much influence, and it is more pleasant to dwell on Mr. Zuhorst's arguments for those aspects of the conservation movement of which he approves than to rebut his arguments. Some conservation groups do need deflating, but *The Conservation Fraud* leaves that need unfilled.

Two widely circulated paperbacks aimed primarily at youth also are disappointing. Both *Ecotactics: The Sierra Club Handbook for Environment Activists* and *The Environmental Handbook*, produced by Friends of the Earth, are replete with good intentions, and both have segments that are excellent by any standard. But both also are full of errors of fact and violent rhetoric calculated more to set nerves on edge than to enlighten.

Admittedly, our present situation is bad, and a good deal must be done quickly to restore ecological sanity. But the remedies offered in these two books hardly seem likely to get those things done. Most of the programs described in both books seem to be based on the touching juvenile belief that the symbol is as good as the deed. We are told that students do good by burying new cars, dressing up in alligator suits and parading on Fifth Avenue, and – the very height of activism – by organising teach-ins. (A teach-in can best be described as a gathering where the already convinced hear repetitive exaggerations.)

Students should be reminded that if you go around telling people that the sky is falling, you are likely to meet the same fate as Chicken Little – that is, the wise old fox will eat you alive. They should also ponder on the fact that in another field of great student activity, we have a national majority that is sick both of the Vietnam war and of the antiwar movement. It is, of course, too much to ask good taste and judgment of student activists with the wild light of instant reform in their eyes, but it would be too bad to see the good cause of ecology defamed by its zealots.

Let the students turn, rather, to Nicholas Roosevelt's *Conservation: Now or Never.* Mr. Roosevelt's record goes back for decades, to great conservation battles won and lost. He has a firm

grasp of both conservation needs and of political realities. There is very little wild music in his book, but there is a great deal of common sense and fortitude. It should be read by anyone interested in knowing where we are and how we got here.

The same is true of *The Environmental Revolution* by Max Nicholson, former director-general of Britain's Nature Conservancy. Mr. Nicholson offers a firm history of the conservation movement, both in the United States and in Europe. Interestingly enough, the view from Britain of the American conservation effort is highly complimentary. Mr. Nicholson believes the Americans are much further along toward protecting their wild heritage than most other nations are. The book is a must for the conservation bookshelf.

A more poetic but no less appealing treatment of the subject is Raymond F. Dasmann's *A Different Kind of Country*. In memorable prose, Mr. Dasmann appeals for preserving wilderness and diversity. He has been in many of the world's remaining wild areas, and his thoughtful, moving description of what the wilderness experience means to mankind should not be missed.

Those who seek a record of what Rachel Carson accomplished should not miss *Since Silent Spring* by Frank Graham, Jr. Naturally, Mr. Graham is an uncritical fan of Miss Carson – it's hard not to be – and he occasionally falls into her error of oversimplification. But like Miss Carson, the message Mr. Graham brings is basically so sound that it strengths are overpoweringly more vital than its few weaknesses. He tells of how Miss Carson wrote *Silent Spring,* how the chemical industry counterattacked, and how the message spread despite that counterattack. Since Rachel Carson, more than any other single indivudual, sounded the ecological alarm, her history is well worth following.

For those interested in the total ecological picture, including the fight to save the cities as well as the wilderness, several new anthologies are valuable. They include *America's Changing Environment,* edited by Roger Revelle and Hans H. Landsberg; *Politics and Environment,* edited by Walt Anderson; and *Challenge for Survival,* edited by Pierre Dansereau. There is enough material available to insure surprisingly little overlap in the coverage given by the three volumes. Any one can stand on its own; reading all three will be equally rewarding.

Edward Edelson

MAN EXPLORES THE SEA. *By Malcolm E. Weiss 110 pp. Julian Messer, New York, 1969.*

Malcolm Weiss, a science editor with Scholastic Magazines, has drawn on his many-facted background in science to do this fine book for young people on man's fledgling efforts to understand and to develop the sea.

Mr. Weiss combines workmanlike accounts of interviews with sea explorers such as aquanaut Scott Carpenter with solid discussions of marine science. In his lively style, he writes of the sea and its cycle of life, its resources that can be either developed sensibly or overexploited, and the overwhelming need for man to move with extreme caution as he proceeds into the last Earth-bound frontier.

At a time when man threatens to pollute the very sea from which his remote ancestors crawled, Mr. Weiss' book is important reading for young people, and adults as well. He places the situation in proper perspective, and his book is a sound plea for consciencious approach to development of marine resources.

E.R.R.

ABOUT THE authors

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ILLUSTRATION CREDITS

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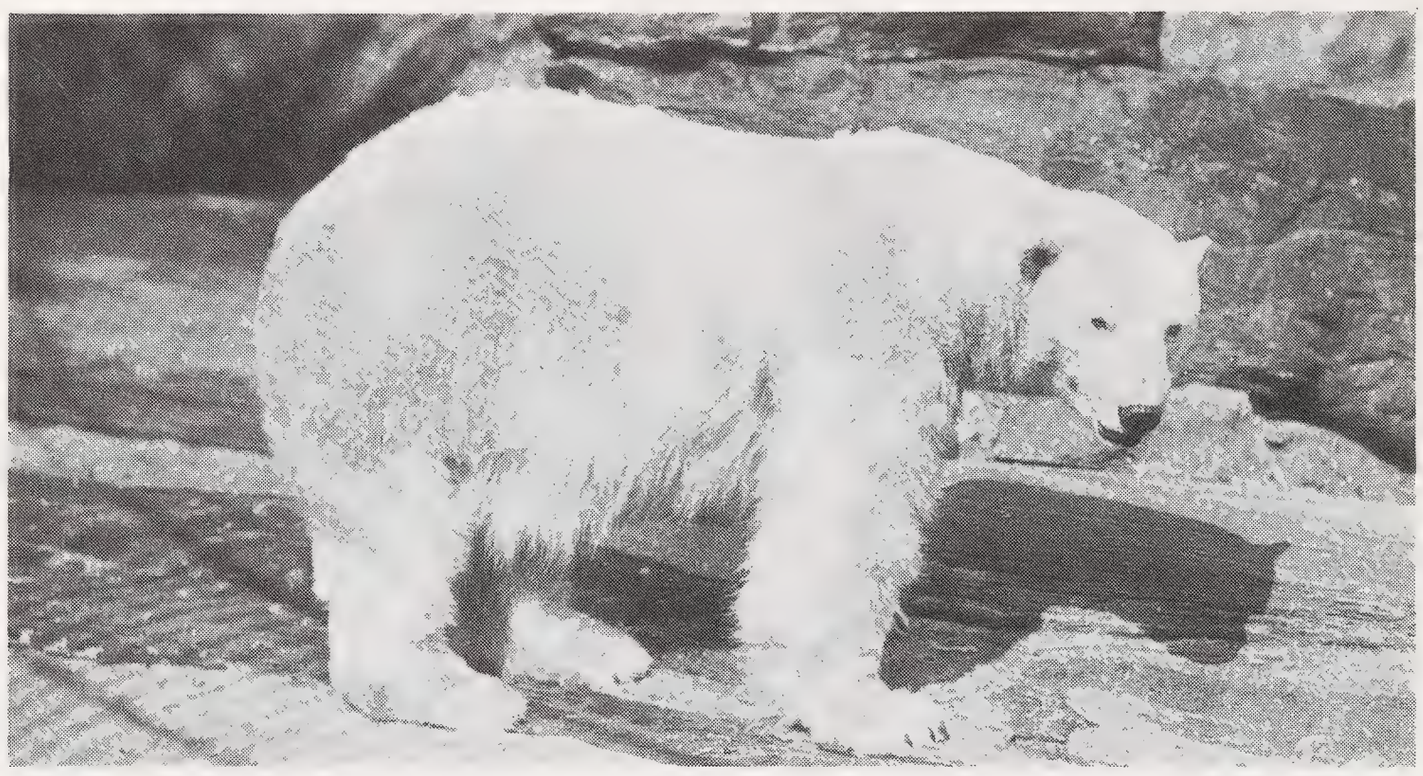
DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo



Polar Bear

Thalarctos maritimus

The inhospitable and seemingly barren floating pack ice encircling the North Pole forms a habitat for one of the most well-known arctic animals, the polar bear. This species is particularly well adapted to life under harsh arctic conditions. It is found farther north than any other quadruped with the possible exception of the arctic fox, which often follows the bear to feed on the remains of its kills. The polar bear's fur is dense and well-oiled, therefore it does not hold water and freeze. Moreover, a thick layer of subcutaneous fat reduces heat loss, thus protecting the animal against the cold.

The polar bear, the most aquatic of all bears, is a powerful swimmer and individuals have been seen swimming far from lands. It swims almost entirely with its front legs.

This species is the most carnivorous member of the bear family and preys largely on seals. A bear will take a seal while on land or as a seal comes to a hole in the ice to breathe. It is rare for a polar bear to catch a seal in open water, for the speed and maneuverability of a swimming seal cannot be matched by a bear. Young or sick walruses, along with fish, carrion, and occasionally birds, also are eaten by polar bears. During the brief summer the bear feeds on mosses, lichens, grasses, and eggs, in addition to its usual prey.

Though the polar bear is found in North America, Europe, and Asia, relatively little is known about it. Some authorities believe it is a migratory species. If so, the killing of bears in Alaska may also show its effect on the bear populations in Russia or Canada. Excessive hunting is the prime reason for the declining numbers of polar bears, but fragile ecological and environmental changes may be exerting unknown influences on the species.

When whaling began to be an unprofitable business because of the scarcity of whales, many whalers turned to hunting seals. Not only did these hunters kill the seals on which the polar bear feeds but they also killed the bears, which they considered a threat to the sealing industry. Snowmobiles, motorboats, and rifles have made it relatively easy for Eskimos and other northern peoples to hunt the bear. However, the number they take has not been large. Today it is the "sportsman," who goes north for his polar bear trophy, who is jeopardizing the future of this remarkable mammal. Many hunters now seek polar bears by air. During the last five years the annual kill by sportsmen in Alaska has been between 200 and 400 bears with the total slightly increasing because of hunting with helicopters and small planes. In 1956 the U.S.S.R. imposed a ban on polar bear hunting in the Soviet Union, following the recommendation of the International Union for Conservation of Nature and Natural Resources that *all* countries within the range of the polar bear should protect it.

The circumpolar distribution of this species has put it in an awkward position. Because most bears are shot outside the 12-mile-limit, where, theoretically, local authorities have no control, an international agreement to restrict or regulate the hunting of the polar bear is required before its numbers diminish to a point where the species can no longer survive. It does not seem reasonable to allow this hunting to continue when we know so little about the polar bear and such facts as its numbers and migratory habits.

JAMES G. DOHERTY

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ABOUT THE COVER

Front: Swinhoe's pheasant *(Lophura swinhoii)* of Formosa is classified in the Red Data Book on birds of the International Union for Conservation of Nature and Natural Resources as "very rare and believed to be decreasing in numbers . . . giving cause for considerable anxiety." **Back:** Orang-utan *(Pongo pygmaeus)* of the forests of Borneo and Sumatra is reported in the mammal "red book" as "rare," having "declined drastically in the past hundred years." For an editorial by William G. Conway, General Director of the New York Zoological Society, on the question of endangered species and recent legislation, see page 2.

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"WHAT'S ENDANGERED"?

New Legislation Fails to Come to Grips with a Difficult Problem

An Editorial by William G. Conway

The trade in wild animals and their products has always been international. In North America, the spread of colonization followed upon the heels of fur trappers who sought their quarry from Louisiana to Hudson Bay and sold their catch in Europe. They decimated the beaver and the otter, destroyed the sea mink, and very nearly eliminated the sea otter. Today, the United States has become the market and American money is behind the slaughter of untold numbers of animals around the globe — to supply American women with "fun furs," men with "gentlemen's fashions," laboratories with monkeys for experimental use, submarines with whale oil, and dogs with whale meat. Nevertheless, a new sensitivity seems to be developing in this country, and a welter of new laws recently have been passed to protect other people's wildlife from our commerce.

In New York State, the "Mason Law" was enacted to protect leopards, jaguars, tigers, cheetahs, and other animals threatened by the skin trade. Similar new statutes recently enacted are the more general New York State "Harris Law" and the Federal Endangered Species Conservation Act of 1969. Unfortunately, the most important of these laws, the federal endangered species act, has serious failings.

It fails to protect the very species that truly are endangered by United States commerce. The endangered species act protects a list of species compiled by professionals in the United States Department of the Interior and experts from all over the world. The list, prepared after the law was passed, contains 131 mammals, 118 birds, 22 reptiles and amphibians, several fish, and one mollusc. As published June 2, it included such rarities as the Bali tiger, which is extinct; the Tasmanian thylacine, which is extinct or nearly so; the Argentine pink fairy armadillo; McNeill's deer of China and Tibet; the Australian Eyrean grass-wren, the Palau fantail, and the Martinique brown trembler (a bird).

Initially, the list also included the sperm whale and the baleen whales, but these were promptly withdrawn for further consideration when the whale oil industry challenged the Interior Department. The new list denied protection to the Bengal tiger, the snow leopard, the African cheetah, the African leopard, most otters, the jaguar, and the majority of other animals actually subject to substantial commerce. (The list does protect a number of species threatened by deterioration of the environment and human population growth.)

For the most part, however, the vaunted "United States' List of Endangered Foreign Fish and Wildlife" is a mockery, protecting the species it covers from the threat of a trade which does not exist. There are probably less than 200 kouprey, large wild cattle, left in Cambodia and less than 100 white-headed guans in Trinidad. Both are on the list and rightly so, for they should be protected. At the same time, however, an animal threatened indirectly by the destruction of its forest, or even directly by pesticides and local hunting for food, constitutes a different case than one threatened by commercial exploitation. Admittedly, it is difficult for Americans to protect tigers and leopards in India from the expansion of that land's teeming population. However, we do not have to encourage direct slaughter of the great cats by allowing their skins to be sold in our country, expecially when India is trying to protect her big cats and to stop poaching. If the Endangered Species Conservation Act of 1969 is to be applied only to those species already on the very brink of extinction and not abundant enough to be subject to our commerce, it is useless.

If the endangered species act is to be of value, its protection must be applied to animals whose numbers are still sizeable, species being killed by the hundreds or thousands for the American marketplace, otherwise these animals, too, will disappear.

During 1968 and 1969, 17,490 raw leopard skins, 23,347 jaguar skins, 262,030 ocelot skins, and 99,002 skins of foreign species of otters were imported into the United States. Ironically, at a recent hearing on protective legislation, one furrier claimed that the number of animals killed proved that they were in no danger, an argument appropriate to a buffalo hunter. Unfortunately, we do not know how many leopards or jaguars exist, only that their ranges are shrinking daily and that observers almost everywhere are noting the gradual disappearance of these animals. Where we do have figures, they are often shockingly low.

Today, the cheetah may be seen in numbers in only a few places. Dr. George B. Schaller tells me that studies by biologists in the famous 7,340-square-mile Kruger National Park of South Africa have shown that cheetahs there number only about 250 individuals. In the renowned Serengeti Plains of Tanzania, the cheetah population is about 150 animals. In other words, there are only 400 cheetahs remaining in a protected area as large as Massachusetts and Connecticut combined, one cheetah for every 30 square miles.

Perez Olindo, Director of the National Parks of Kenya, wrote of illegal poaching of cheetahs in Kenya to the New York State Legislature. He pleaded for protective legislation restricting the sale of skins of leopards, cheetahs, and crocodilians in the United States marketplace. Despite his pleas and the protective conventions of most African nations, our new endangered species law does not consider African cheetahs endangered.

This brings up the question: what is an endangered species? It is not only a question of numbers.

One biologist I know takes the view that a species with a population below 2,000 is endangered and one with more is not. This is rubbish. While any animal with less than 2,000 conspecifics has every reason to feel insecure, many with larger populations also are endangered. Numerical standards of endangerment do not work at our present level of ignorance. Colonial birds are a case in point. Any bird reduced to a single nesting location is living precariously no matter how many thousands of birds may be nesting there. The record of extinction of island birds is shocking.

Of the 53 species and 52 subspecies of birds which have disappeared in the last 290 years, 50 species and 47 subspecies were island forms. Federal officials have put 65 island birds on the new federal endangered species list. However, almost none of these island species ever are imported commercially.

On the other hand the status of many more widespread animals is remarkably clouded. And most of the species subject to the import trade are in this category.

The Red Data Books of the Survival Service Commission, a wing of the International Union for Conservation of Nature and Natural Resources, are the recognized standards on the general status of rare animals. (The Red Data Books are available at the Union's offices at 1110 Morges, Switzerland.) They place "rare and endangered forms" in four categories:

1. ENDANGERED. In immediate danger of extinction; continued survival unlikely without the implementation of special protective measures.
2. RARE. Not under immediate threat of extinction, but occurring in such small numbers and/or in such a restricted or specialized habitat that it could quickly disappear. Requires careful watching.
3. DEPLETED. Although still occurring in numbers adequate for survival, it has been depleted considerably and continues to decline

The Siberian tiger is classified as critically endangered by the IUCN, yet it is not on the "United States' List of Endangered Foreign Fish and Wildlife."

at a rate which gives cause for serious concern.

4. INDETERMINATE. Apparently in danger, but insufficient data currently available on which to base a reliable assessment of status. Needs further study.

While helpful, these definitions are too vague and too broad. Moreover, the omission of a species from the list has been cited by fur traders as what amounts to a license to kill. All it really means is that the Survival Service Commission has not yet received adequate reports on whether or not the animal is in serious trouble.

The definition of endangered has been seriously confused by a remarkable statement from the United States Senate Commerce Committee. In its report No. 91-526, it instructed, with regard to the new endangered species act, that:

> ". . . the committee would also stress that a given species or subspecies may be placed on the endangered list only when it is threatened with worldwide extinction; a serious reduction in numbers in a single country is not an adequate basis for placing a species or subspecies on the endangered list when that same species or subspecies is plentiful elsewhere."

With these words, the Senate neatly emasculated the basic purpose of the legislation.

Pumas, for instance, range throughout North America, Central America, and South America. In some places, the puma remains common, but in most areas it is rare and declining in numbers. Surely the big cat is on the road to extinction over much of its range. In fact, two races of puma are listed as depleted in the Red Data Book. But, according to the Senate Commerce Committee directive, because pumas still exist in some numbers over wide areas, they do not deserve protection from commercial exploitation.

In point of fact, however, is the puma "endangered" if there are one or two healthy populations somewhere, say in Argentina? Does it matter if all the pumas in Canada, the United States, Mexico, Guatemala, and Peru are killed to make gentlemen's fall fashions, as long as there are some

pumas in Argentina? Can we depend upon the Argentines to protect all the world's pumas? Clearly, the need for a valid concept and definition of an "endangered animal" has become crucial.

There must be logical criteria for calling a species endangered, for the implementation of laws that protect foreign wildlife from the United States marketplace. These criteria should satisfy the commercial pressures for utilizing healthy wild animal populations without endangering the existence of the species, just as American hunting regulations generally satisfy the pressures to kill wild animals for sport. In my view, there are five clear commandments for designating a species endangered by commerce:

1. Prohibited species should be animals which are threatened by commerce and actually imported or likely to be imported.
2. The protected list should include those species subject to regular importation but not being taken on a sustained-yield basis. And the burden of proof should lie with the importer.
3. Where endangered populations or subspecies of an animal may not be distinguished surely from more abundant populations, the full species must be protected.
4. Species listed should be those whose ranges or populations are shrinking or already small.
5. Animals should be protected with the objective of maintaining wildlife populations large and widespread enough to fulfill their ecological roles, and to withstand natural disasters such as drought and disease, and predictable man-made catastrophes such as oil slicks.

Surely, the first principle is obvious. Why protect the Mexican grizzly bear, which is apparently extinct and which has never been imported, and ignore the polar bear whose skins are imported and whose population has been the concern of conservationists for years?

The second rule, requiring importers to operate on a sustained-yield basis, is simply common sense. A farmer who sends as many chickens to market as he can without regard to the size of his flock and the next year's production of chicks will soon be out of business.

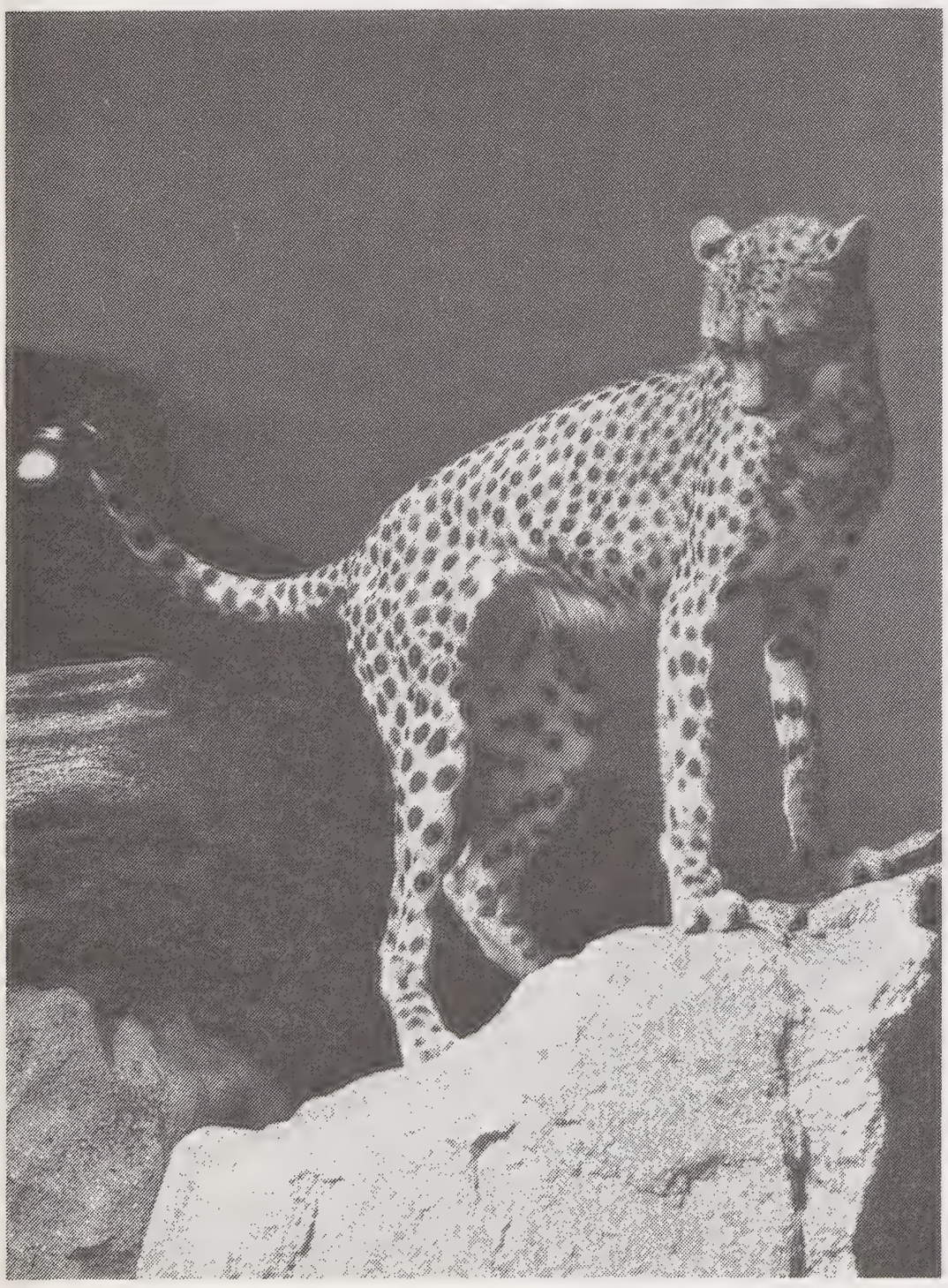
Healthy populations of most wild animals will produce more young than can survive within their limited habitats. This surplus can be killed without endangering the breeding population. A classic example is that of the Alaskan fur seal of the Pribilof Islands.

At the turn of the century the great seal herds were subject to unmanaged slaughter, like that going on today with the big cats, the otters, the whales, and the crocodilians. Finally, less than 150,000 fur seals remained. Only then did the United States, Russia, Japan, and Canada sit down and draw up a treaty which eliminated pelagic sealing and put the United States in charge of managing the Pribilof herds on a sustained-yield basis. Today, the seals number more than a million and annual harvests of up to 50,000 seals are possible without endangering the species, because careful census techniques guide a limited and managed kill.

It is still slaughter and still repugnant, but the seal's commercial value has helped protect the future of its kind. Perhaps now the fur seal has a chance of being preserved until man reaches a higher level of understanding and intellect and once and for all gives up killing wild creatures.

The same management principles are not observed for the big cats or for any other wild land animal killed for the United States fur and hide industry anywhere in the world. For example, the industry does not know how many cheetahs there are, it does not manage them in any way, and it takes as many skins as the market will consume or that it can get. Yet the only cheetah on the federal list is the Asiatic cheetah which is nearly extinct.

The African cheetah, which is not on the federal list, is diminishing in numbers. The Asiatic cheetah, which is listed, is extinct or nearly so.



It is reasonable to continue to import Alaskan fur seal skins so long as it can be demonstrated that the herds are carefully managed, and it is logical to stop the importation of cheetah skins until it can be shown that the future of this species has been studied and provided for.

The application of the third principle demands an understanding of speciation and the way animals have been added to the endangered species list. Many geographic populations of wild animals are subspecifically distinct. The federal list protects certain local races whose status is known to be precarious but, following the Senate Commerce Committee directive, not the whole species. Thus the Sinai leopard *(Panthera pardus jarvisi)* and the

Morelet's crocodile (above) is classified by the IUCN as critically endangered; it is not on the federal list. Three relict subspecies of the leopard (at right) are listed, but populations elsewhere, threatened by the fur trade, are not.

Barbary leopard *(Panthera pardus tulliana)* are listed – but not the many other races of leopard now being killed by the thousands for fur coats. Following our puma analogy, the new federal list would allow the last Kenya leopard to be poached and its skin sold in Chicago, for there might be a healthy population of the same race in Tanzania or someplace else.

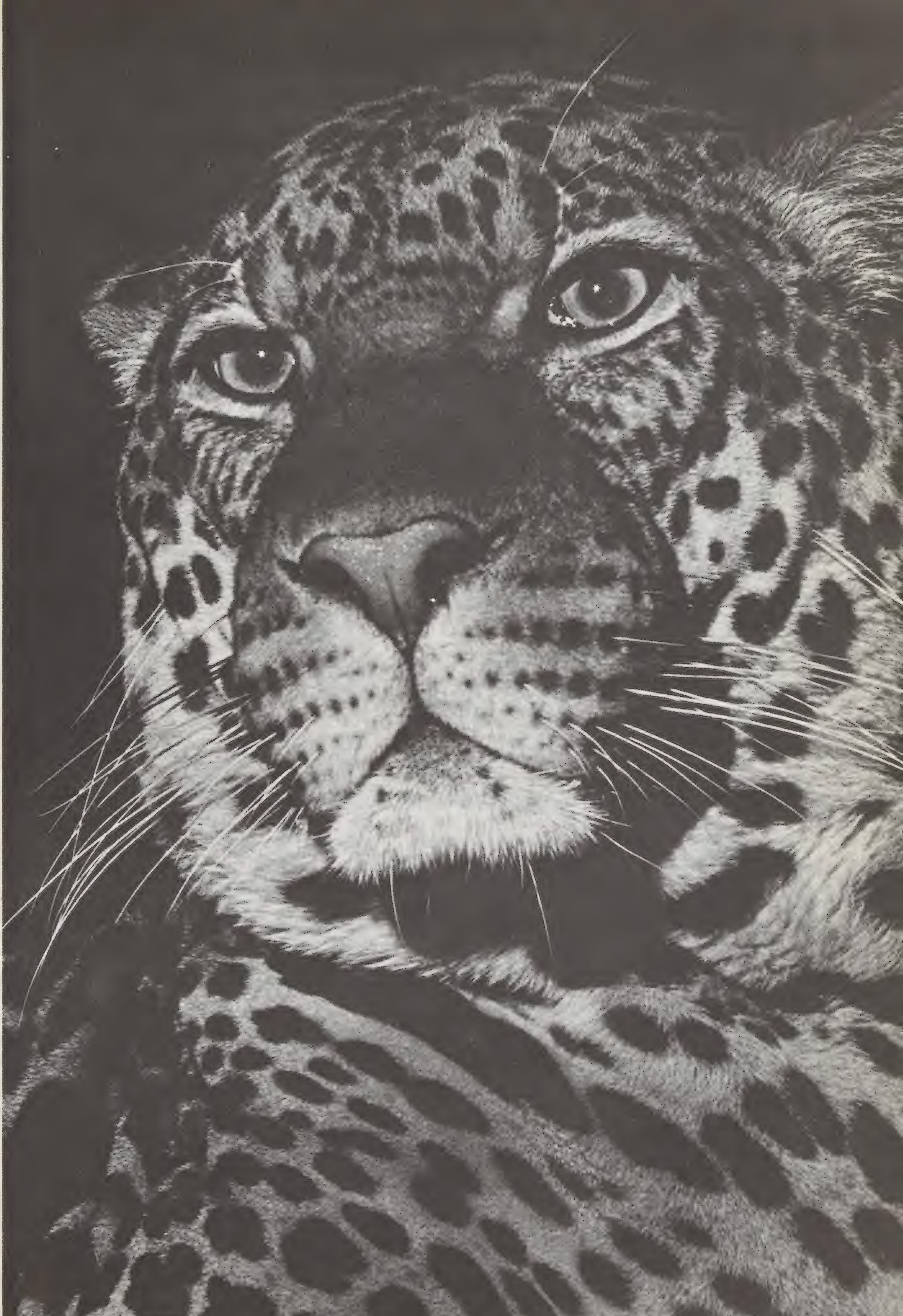
In actual practice, an experienced taxonomist can normally separate about 85 percent of the specimens of one subspecies from those of another in the same species. The distinctions between races may involve only size, gradations of color, average length of hair, and obscure skeletal characteristics.

For instance, the Sumatran tiger, which is on the protected list, differs from the unlisted Bengal tiger in having more numerous stripes, a little less white in its coat, and being slightly smaller – usually. But the Bengal's color pattern is so variable that often the hides of young specimens cannot be distinguished from that of Sumatran, Javan, or Bali tigers. It is almost hopeless to try to identify an animal's race – one kind of tiger from another – from the fragments found in coats, mufflers, purses, and other finished products. The only way a list of proscribed animals can protect rare regional populations or subspecies is by prohibiting the importation of the full species with all of its races and populations. Otherwise the law will be unenforceable.

The fourth rule, that species protected from importation should be those whose range or population is shrinking or already small, is easily applied to some animals but not to others.

Consider the case of the world's great whales: for years whale experts have been dismally consistent and accurate in predicting decreasing whale numbers and catches. Each year their predictions have been accompanied by recommendations that the catch be restricted. Just as consistently, their recommendations have been ignored by the whaling nations.

When the giant blue whale, the humpback, and the right whale became too scarce to catch in Antarctica, the whalers turned to the fin whale. After reviewing whale populations in 1963, biologists predicted that, if unrestricted whaling continued in the 1963-64 season, a dangerously high number of the diminishing fin whales would



The sea otter, once nearly eliminated by fur trappers, is now recovering. The IUCN lists a subspecies as depleted; the sea otter is not on the federal endangered species list.

be taken. They estimated 14,000 individuals; 13,780 fin whales were killed. The following year, the whalers could find only 7,308 to kill. Rather than return with empty holds, they killed 20,000 sei whales, a third of the total population of this species. There is no question that the whales are in trouble.

In contrast to whales, the populations of many forest animals are a mystery. We may not realize the danger these creatures face until they become so rare and localized they are almost gone, like the Zanzibar colobus monkey. It is a case of not being able to see the monkeys for the trees. Nevertheless, 634,000 live wild monkeys of several species were imported into the United States from 1958 through 1960. Most were purchased for laboratory use, many were bought for the pet store trade, and the commerce in monkeys continues. In 1968, 124,440 monkeys were imported. Although the high purposes of importation of monkeys for research may be more understandable, its effects upon wild animal forest populations are just as dangerous as those of the skin trade.

Hiding in the forest is harder for the tiger. Although its numbers may have exceeded 40,000 at the turn of the century, a recent IUCN report offers the following present-day estimates:

*	Caspian tiger	Iran	15-20
		Afghanistan	a few
	Siberian tiger	Russia	60-70
		China	about 50
		Korea	40-50
	Chinese tiger	China	a few
	Indo-Chinese tiger	Yunnan	
		Burma	
		Thailand	?
		etc.	
*	Sumatran tiger	Sumatra	?
*	Javan tiger	Java	10+
*	Bali tiger	Bali	extinct
	Bengal tiger	India	1,900-2,500
		Pakistan	50-100

**On the United States List of Endangered Foreign Fish and Wildlife.*

It is incomprehensible that all the different kinds of tigers were not placed upon the endangered species list. Even the most optimistic estimates of the most abundant race place its numbers at less than 3,000. The need for adequate criteria for designating animals "endangered" could hardly be more clear. After all, if an animal's status is truly questionable, it should be given protection until the matter is investigated. Let us postpone a few private profits to error on the side of conservation. If a mistake is made on behalf of short-term commerce, extinction is irreversible.

The Philippines monkey-eating eagle, of which fewer than 100 still exist in the wild, is on the federal list.

Listed by the IUCN as rare, the polar bear is not on the Department of Interior's endangered species list.

The fifth and final principle, in the protection of wild animals from commercial exploitation, is basic to the idea of conservation itself. Part of the intent of the endangered species act was to preserve sizeable populations of wild animals. When a species is clearly in danger of "world-wide extinction," on the other hand, the value of protecting it is small. By this time, it has little chance of recovering and none of playing out its role in the scheme of natural communities.

Our aim must be to preserve significant populations of as many wild creatures as humanly possible. The importation ban is futile play-acting if we are not attempting to prevent destruction of commercially-endangered wild creatures. The law must concentrate upon, not avoid, the plight of those exploited species which still range widely enough over their original homelands to give some hope for potential survival and continued contribution to the earth's ecology.

Fortunately, there are signs that reason may prevail in some parts of the animal products industry. In August, the Furriers Joint Council of New York announced that its members will not "cut, fashion, or fabricate" skins of tigers, leopards, cheetahs, jaguars, and other animals threatened with extinction by a demand for their hides (not a great hardship, for more than 98 percent of the fur business comes from minks and other ranch bred animals). Unfortunately, the exploitative stand of management in the American fur industry is at disgraceful variance with that of the workers and with the attitude of the German furriers, who recently voted a voluntary ban on the importation of leopard, tiger, and jaguar skins and asked their government to take immediate steps to pass protective legislation.

To the best of my knowledge, not one American fur or hide company has yet conducted any serious scientific research upon any of the wild creatures whose lives sustain part of their business. Not one has made any attempt whatsoever to operate on a sustained-yield basis which might be expected to preserve the living resources it is exploiting. Few fur or hide company officials have any real knowledge of the natural history or the population dynamics of the species with which they deal. Some cannot even identify skins and hides properly, although they can grade their quality within a hair.

Yet, the animal products industry is challenging the protection of species ranging from whales to leopards and claiming, among other things, that too little is known about these wild animals for them to be designated endangered by zoologists.

There is a need for more information on the populations and the future of species that are being exploited commercially. Why not let the industry contribute toward the financing of such research through a tax on skin importations? According to the Department of Commerce, the value of the jaguar skins imported in 1968 was $1,466,272; cheetah, $169,264; ocelot, $5,915,504; leopard, $2,267,638; a total of $9,818,678 for the four species. Even a two percent tax on value would support a significant research program, which would help us to better preserve the big cats and the fur business, too.

COLLECTING FISH IN BERMUDA

by U. Erich Friese

With the distinct, slightly muffled sound of a hermetic seal, the cabin door of the Boeing 707 aircraft thudded shut. The large airplane nosed away from the loading ramp and taxied toward the runway, and New York Aquarium tankman Peter Fenimore and I, were on our way to collect fish in Bermuda and send them back to the aquarium.

Thorough planning and much hard work had gone into the preparations for this collecting trip. From long packing lists a multitude of items necessary for such a venture had to be purchased, loaned, or simply gathered together and dusted off from previous collecting trips. Plastic bags, oxygen bottle, diving gear, and camera equipment had to be packed weeks earlier and shipped in advance by boat. The largest and most important item consisted of 100 styrofoam boxes in which the fish would be shipped to New York.

The mid-July weather was hot and humid in the Bermuda Islands. Located about 600 miles in the Atlantic Ocean east of the Carolinas, these islands are the beneficiaries of the warm Gulf Stream, which gives Bermuda the northernmost formation of coral reefs in the Atlantic Ocean.

The Bermuda Islands were discovered by Juan Bermudez in 1515, as he sailed aboard the vessel *La Garza* from Spain to Cuba. They consist of about 25 larger islands and a number of rather small islets. Most of the actual land area is included in the largest of the islands (Bermuda), which is about 14½ miles long and barely more than 2 miles wide in some places. The main islands form a sort of crescent about 15 miles long (measured in a straight line). This crescent continues on in the form of an ellipse, with innumerable submerged or nearly-submerged flat reefs. Many of these are exposed at low tide. While this entire area covers about 220 square miles, the inhabitable land occupies only about 20 square miles. Generally, the land area lies fairly low, but it is still diversified with hills and dales throughout. Initially, large areas of the Bermuda Islands were covered with groves of cedar, *Juniperus barbadensis.*

This growth has now been replaced by many exotic trees introduced by the settlers. There are no natural lakes or freshwater wells on the islands. The entire water supply has to be collected from precipitation.

Louis Mowbray, the (now retired) director of the Bermuda Government Aquarium, had courteously arranged for the custom clearance of all our gear shipped earlier by boat to Hamilton, the port of Bermuda. Our equipment also had been

During the New York Aquarium fish-collecting expedition in Bermuda, an outboard motor boat was used to visit the trap locations (above). The 55-foot yacht *Rockfish* (at right), which had a live-well on board, was used for collecting trips around the Bermuda Islands and for transportation of the collected specimens to the airport for shipment to the New York Aquarium.

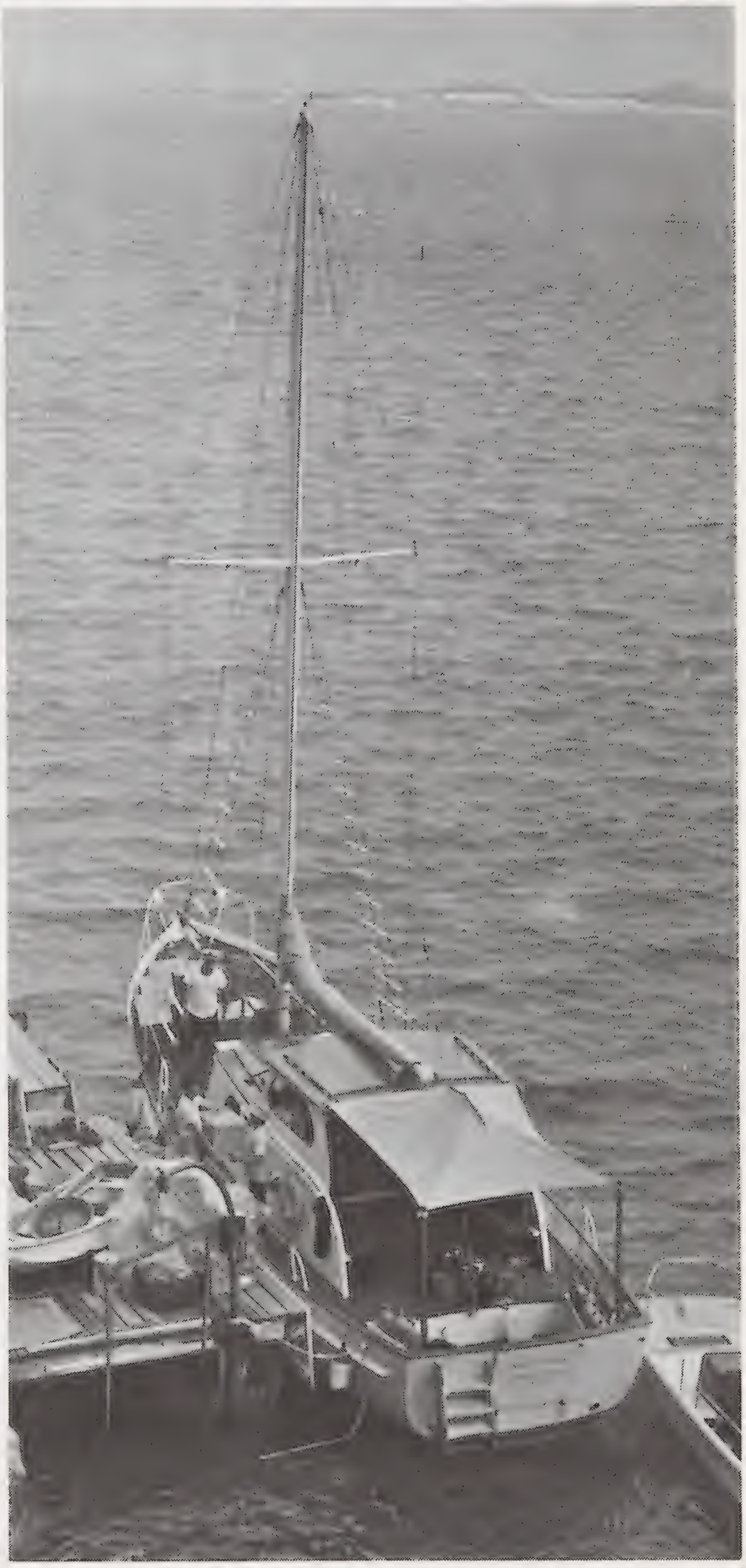
transported to the Government Aquarium at the Flatts Inlet, which was to be our main base of operation.

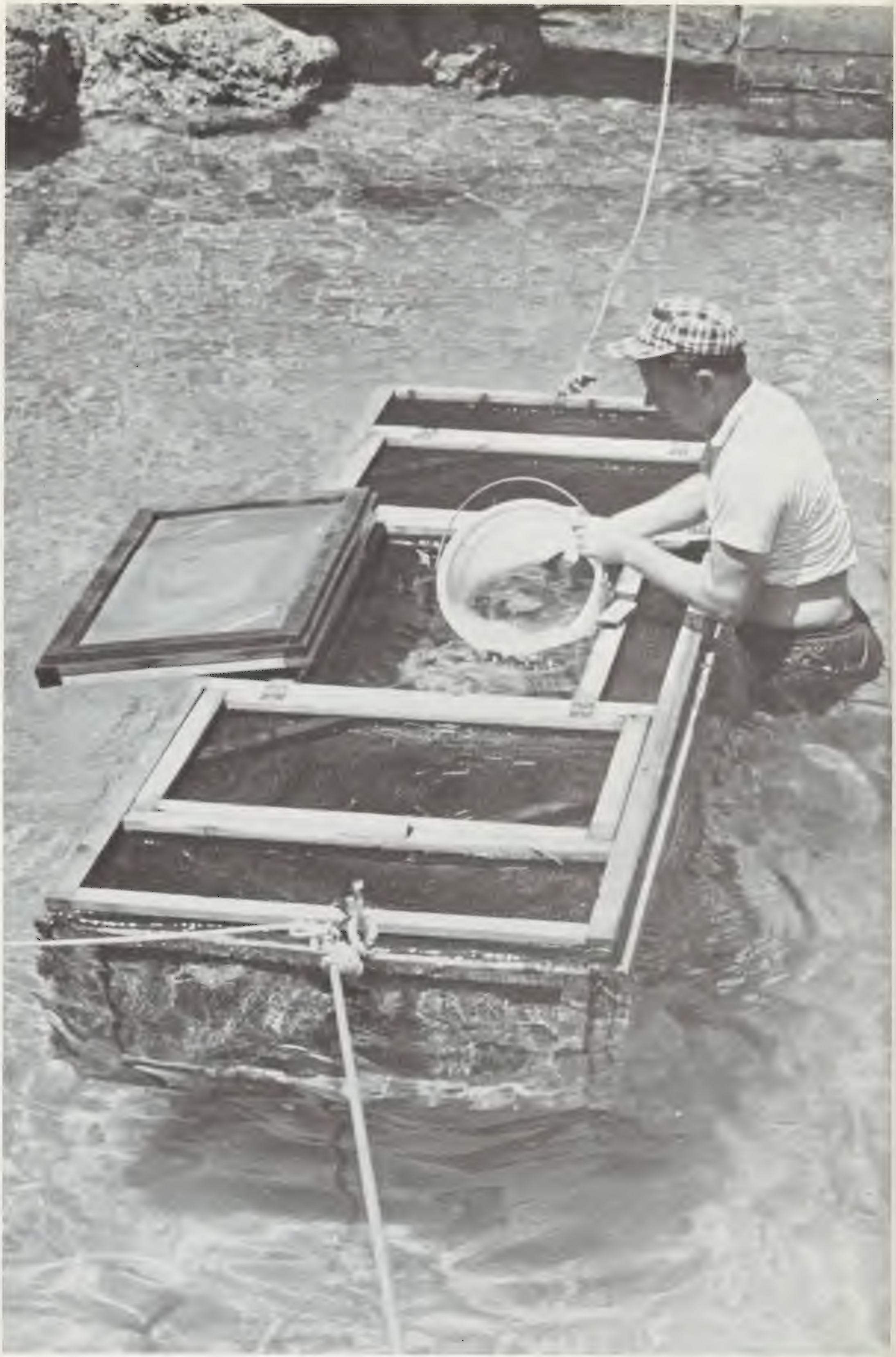
Refreshed after a night's sleep, we made plans for the transfer of some of our equipment to our field headquarters near the fish-collecting areas around Castle Harbor. On rented motorcycles, we followed the loaded truck along the typically narrow and winding roads. We passed Harrington Sound, the famous Devil's Hole, and finally drove toward Castle Point along 100-foot-cliffs above the gleaming beaches of the south side of Bermuda Island.

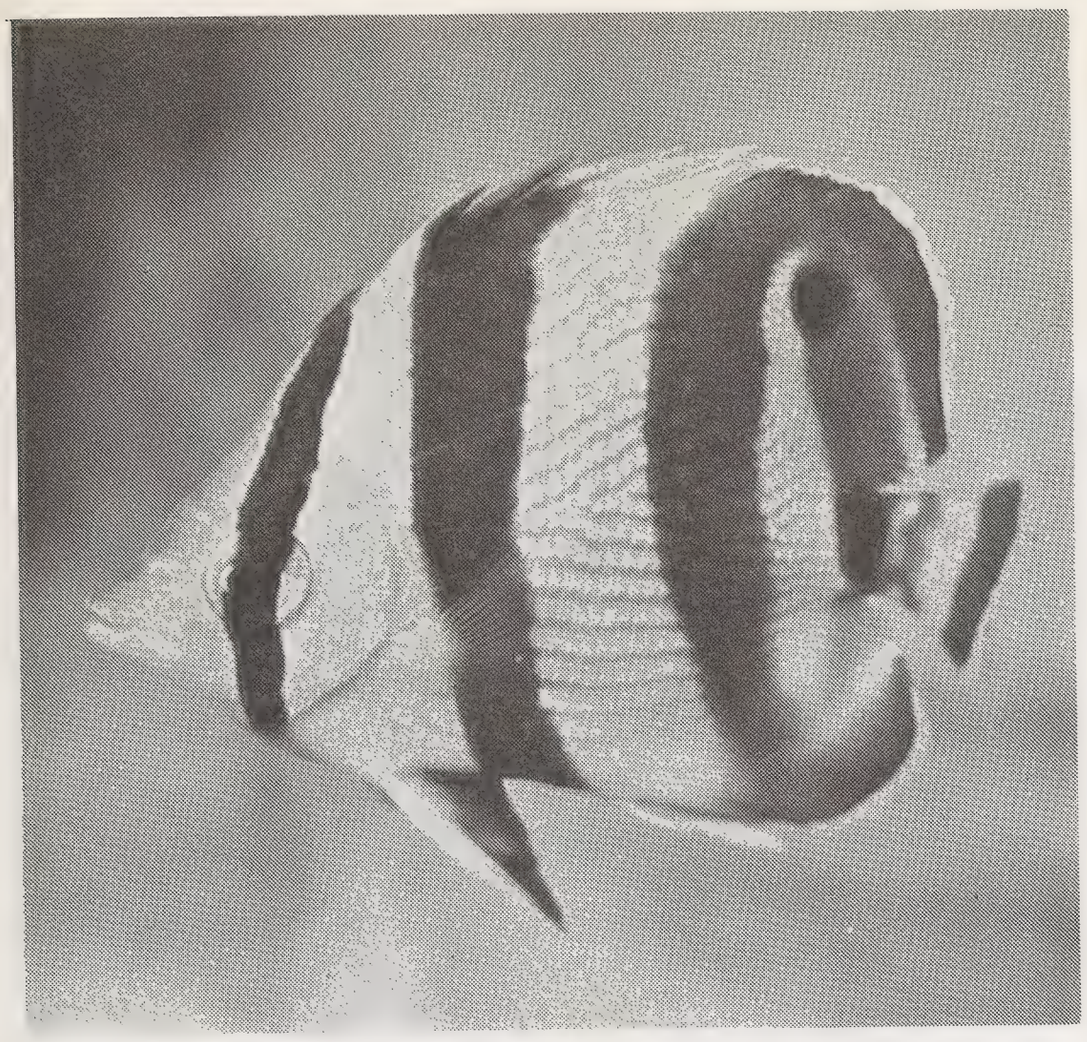
Here, at the home of Dr. Henry Clay Frick, II, New York Zoological Society vice-president, we unloaded the truck and stored our equipment. About 50 feet below us, at the water's edge and next to a solid and sturdy dock, there was a tide pool partially carved into the limestone rock. For some time prior to our arrival, Dr. Frick and his family – all very accomplished divers – had been collecting and holding fish for us in this pool.

There, in about 3 feet of water, were some large blue angelfish, *Holacanthus isabelita,* several beautiful parrot fish, *Sparisoma* sp., and two exceptionally large porcupine fish, *Diodon hystrix.*

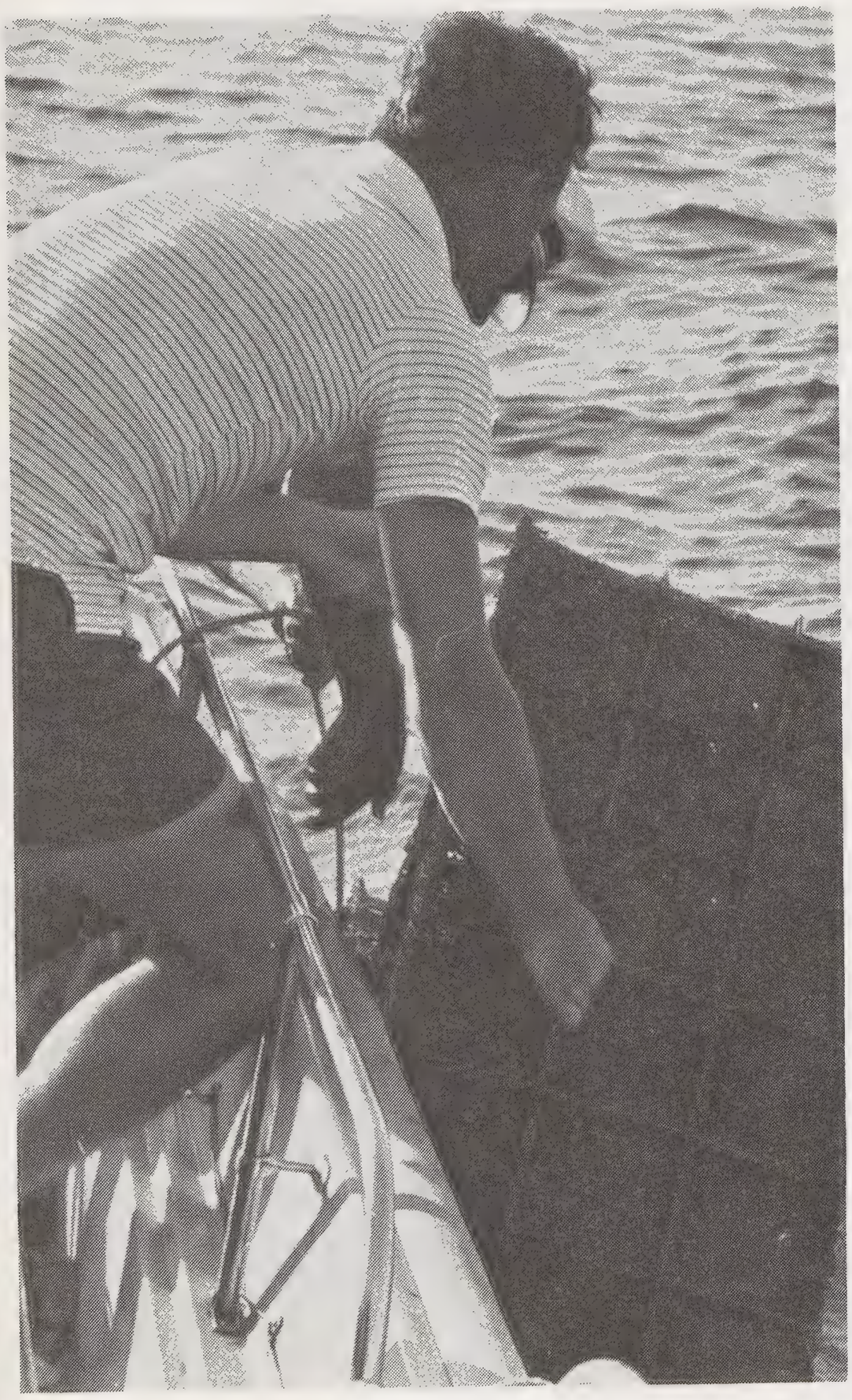
Porcupine fish, or spiny puffers, are somewhat







At the various locations, each trap had to be pulled up by hand and checked for fish twice a day (below). Among the specimens collected was a banded butterflyfish (above). Awaiting shipment, the smaller fish were placed in a floating live-box within the tide pool (at left).



difficult to handle. On the slightest provocation, they blow themselves up with air or water, and when fully inflated, all the spines stand erect. This makes the porcupine fish a problem to ship, since the spines can easily puncture even the strongest plastic bag.

The parrotfish in the pond were particularly welcome to us, since this type of fish makes an excellent display specimen. Parrotfishes are colorful, perch-like fishes which are very abundant on and around coral reefs. They can easily be recognized by their slightly protruding teeth, which are fused into upper and lower plates resembling the beak of a parrot. They feed mainly on vegetable matter and on various invertebrates. Their strong "beaks" can easily crush molluscs and coral. Many parrotfish species reach fairly large size, up to two feet, and while some of them are poisonous at certain times, most parrotfishes are regarded highly as food fish in certain areas of the world.

The large holding pond had a natural opening along one side, which had been sealed off with a plastic screen. It kept the fish inside the pool but also permitted ample flow of freshly oxygenated sea water into the pool. A floating live-box, designed and built with a very fine mesh screening for the smaller specimens, was anchored in the middle of the pool.

Castle Harbor is indeed an ideal location for a fish collecting expedition to Bermuda. The well-known naturalist George Brown Goode once said about Castle Harbor: "This charming sheet of water, the beauties of which, on a bright sunny day, with sufficient breeze to ripple the surface of the azure waters, are not to be excelled in any part of the world, is an excellent collecting place." The entrance to Castle Harbor is overlooked by Castle Island. Here are the ruins of what once was a fort called "The King's Castle," which in its prime had considerable military significance. Numerous submerged ship wrecks in the area give silent testimony to its effectiveness in the days of the sailing ships.

Although many specimens had already been collected before we even got to Bermuda, much of the work was yet to be done in the days ahead. The next few days were spent checking the fish traps twice daily. There were about 10 of these large wire cages. A long rope leading to the sea surface and a buoy for identification marked the location of each trap.

In a small, but powerful and fast, motorboat, Dr. Frick took us to the various trap locations. Bobbing like a cork on top of the ocean swell, often dangerously close to the treacherous reefs, each trap had to

For shipment to the New York Aquarium, the fish were placed in double plastic bags containing sea water and piped-in oxygen, which were in turn placed in insulated styrofoam boxes.

be pulled up by hand and checked for fish. It is essential that the traps are placed as near as possible to the reefs, for this is where the fish are. The multitude of holes, crevasses, and caves in a coral reef provide sufficient diversification of the marine environment, thus permitting the existence of many different species in a relatively small area. On the reef there is ample food for all fish and invertebrates, from the smallest flatworm or coral polyp to the largest shark. Some of the most numerous and colorful reef fish are the various angelfish and the butterflyfish. Most of these are extremely colorful, with markings which stand out dramatically against any underwater background. While color combinations in the butterflyfishes dominate among yellow, red, orange, and some blue, the color green seems to be completely absent.

All butterflyfishes have flexible, comb-like teeth. These fish are usually small; they rarely exceed six to eight inches in length. They seek refuge amongst the branches of coral and are very difficult to dislodge by a diver when the fins have been erected. Most butterflyfishes are more or less solitary in habit. Usually one sees only small groups of four to six fish. Often there are only two fish, usually a mated pair, in a certain area on the reef. This phenomenon is, for instance, typical for the colorful rock beauties, *Holacanthus tricolor,* and the blue angelfish, *Holacanthus isabelita.* While the rock beauty is essentially a deep water fish, the blue angelfish can be found as shallow as five to ten feet, yet both species rarely occur in numbers more than two at a time.

The traps near the reefs also produced several species of butterflyfish *Chaetodon* sp., most of them attractively marked. In abundance were various species of wrasses, such as the pudding wife, *Halichoeres radiatus* (why this fish is called a "pudding wife" I have never been able to find out); the bicolored Spanish hogfish, *Bodianus rufus;* and the bluehead wrasses, *Thallosama bifasciatum.*

Wrasses look almost like small parrotfishes. In fact, they are closely related to the parrotfish, with only differences in teeth formation being the separating factor between the two groups. Some wrasses are reported to build nests for their eggs and young, and many species apparently "sleep" at night. Most wrasses tend to bury themselves by diving into soft coral sand, and thus hide from predators. There are quite often differences in coloration between the juveniles and the adults,

The styrofoam boxes with their protective outer cardboard cartons were loaded on board the *Rockfish* and taken across the harbor to the airport.

which has lead to considerable confusion in the classification of this fish group. Other frequent catches in our traps were moray eels, *Gymnothorax* sp.; some groupers, *Epinephelus* sp.; sergeant-majors, *Abudefduf saxatilis;* and many more.

The fish were transferred from the traps to small holding containers in the boat and then immediately rushed back to the dock. According to size, the fish would be placed either in the pond with the large fish or put into the floating live-box with the smaller specimens.

Between the twice-daily inspection of the traps, other fish collecting ventures were undertaken. The 55-foot motor yacht *Rockfish,* with Dr. Frick at the helm, took us to a number of other places around the Bermuda Islands. John Smith's Bay was a favorite spot for large schools of parrotfish. In order to catch these elusive fellows, a beach seining net, 1000-feet-long, was employed. The net was set across the entire bay, cutting off most of the fish from the open ocean. Both ends of the net were brought together quickly, forming a tight circle around the entrapped fish. As this circle tightened, the fish were confined to an ever-smaller area. Finally, divers went into the water, either snorkeling or with scuba gear, to net by hand the most desirable specimens. These fish were then placed in the large live-well on board the *Rockfish.*

Crawl Point on the north side of the islands was a good spot for some of the spectacular spiny lobsters, *Panulirus argus.* The sandy bottom between Castle Island and Old Castle Island sheltered some of the sand burrowing razorfish, *Hemipteronotus* sp.

Eventually it was time to ship fish back to New York. We arose at 5:00 A.M. and arrived at Castle Point just as the sun came up. Despite the early morning hour, the air temperature already was 83°F.

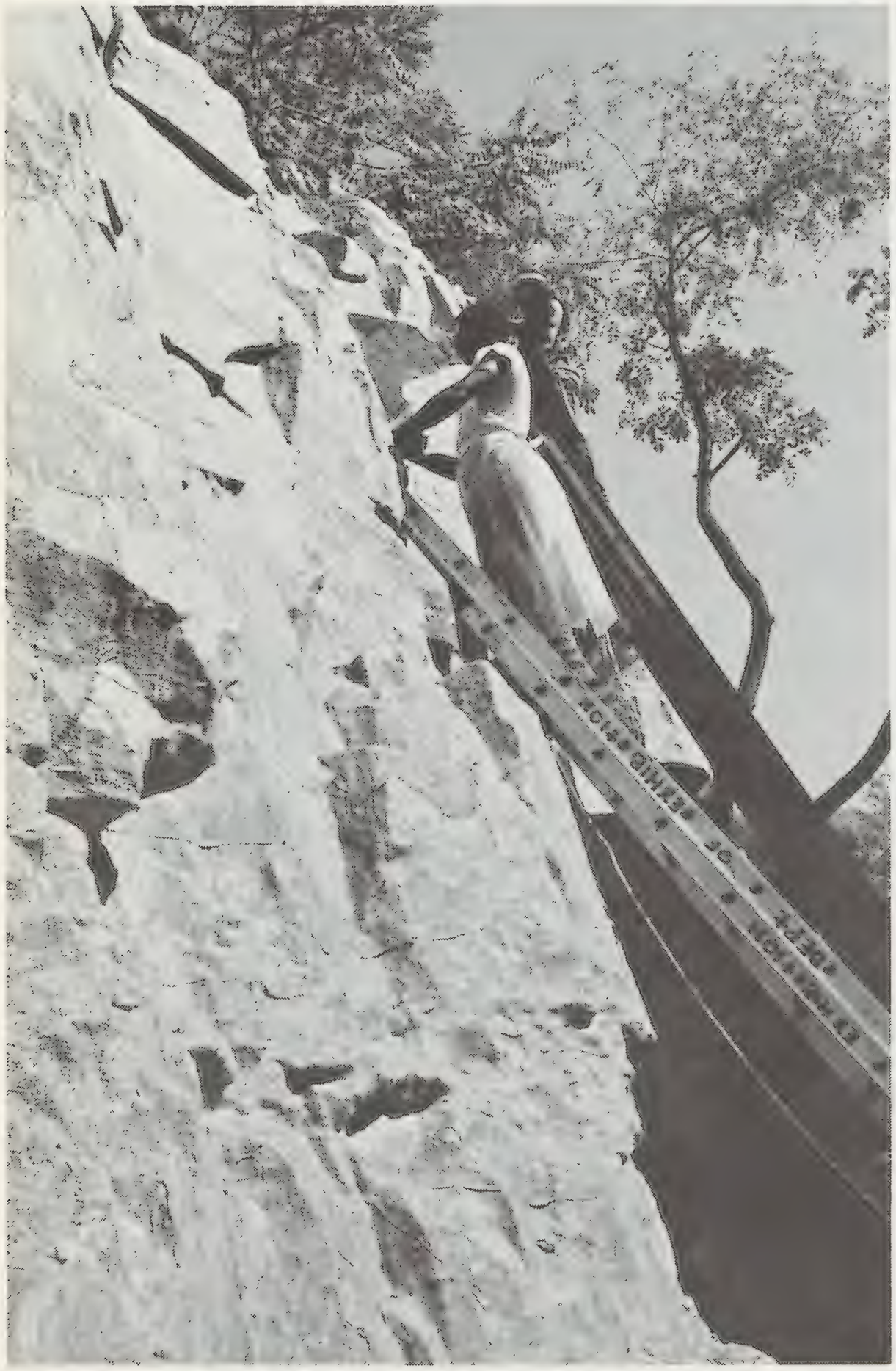
Double plastic bags, each holding about one-half bucket of sea water, were used to hold the fish. The bags were placed in insulating styrofoam boxes. Oxygen was then piped into the bags.

It took three hours to pack the 20 boxes full of fish. At about 9:30 A.M., the *Rockfish* returned from her nightly moorage at St. George Island and tied up on the dock. Without delay the boxes were loaded on board for the 30-minute ride across Castle Harbor to Kinley Field, Bermuda's airport on St. David's Island. Within 15 minutes after arriving at the airport, our fish were on the way to a waiting jet airplane. An hour later the plane was scheduled to arrive in New York, where a truck would take the precious fish cargo to the aquarium at Coney Island.

During our two-week stay in Bermuda, this routine was repeated five times. With the last shipment, a total of 73 boxes containing 373 specimens of 52 different species had been sent to New York City to be displayed at the New York Aquarium.

With a fork-lift and cargo pallet, the boxes were placed on the waiting jet airplane. An hour later, the fish cargo arrived in New York City and was on its way to the aquarium at Coney Island.

"This Is For The Birds"



Casting a Palisades Cliff for the World of Birds

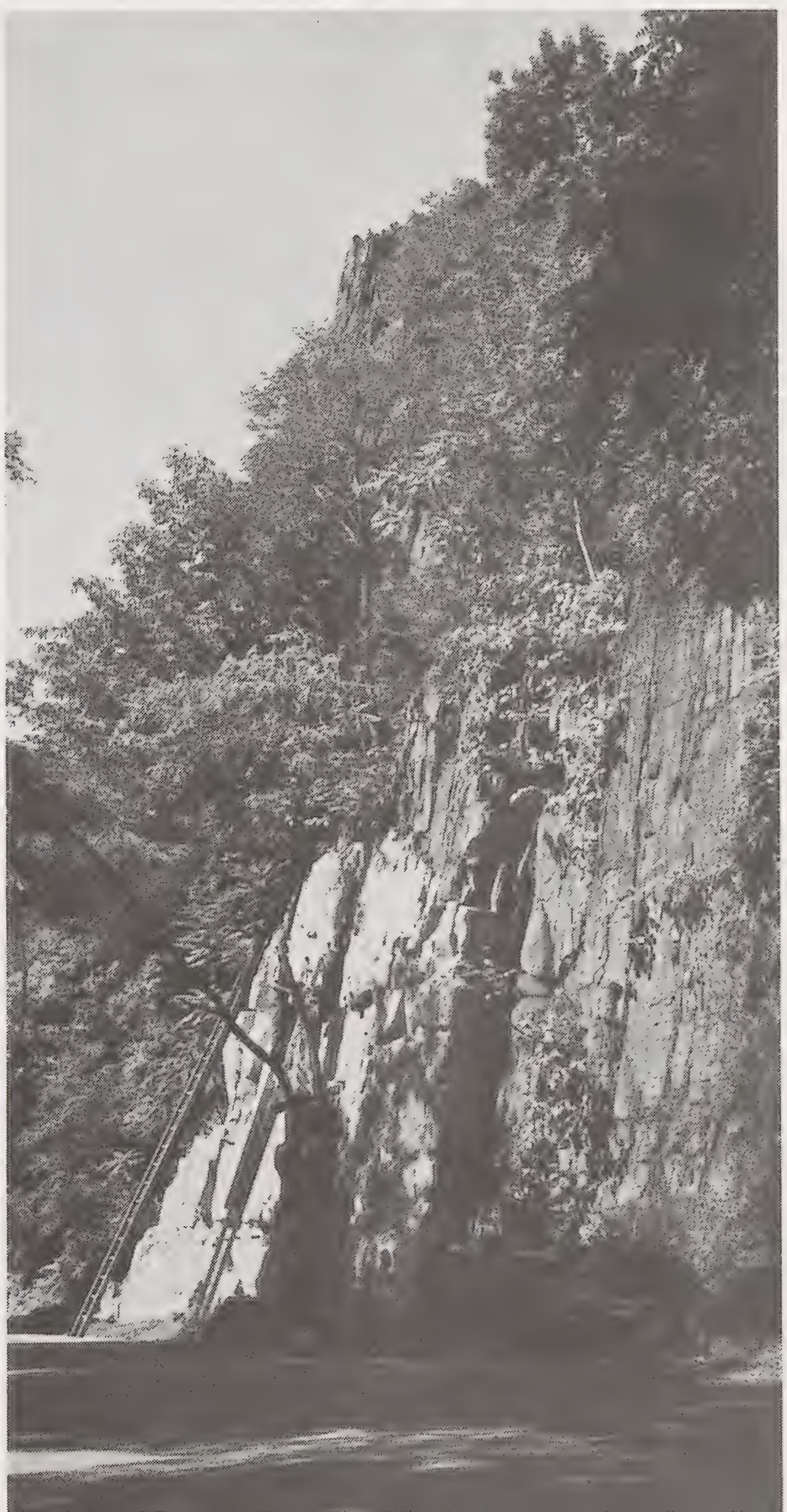
Photographs by Bill Meng

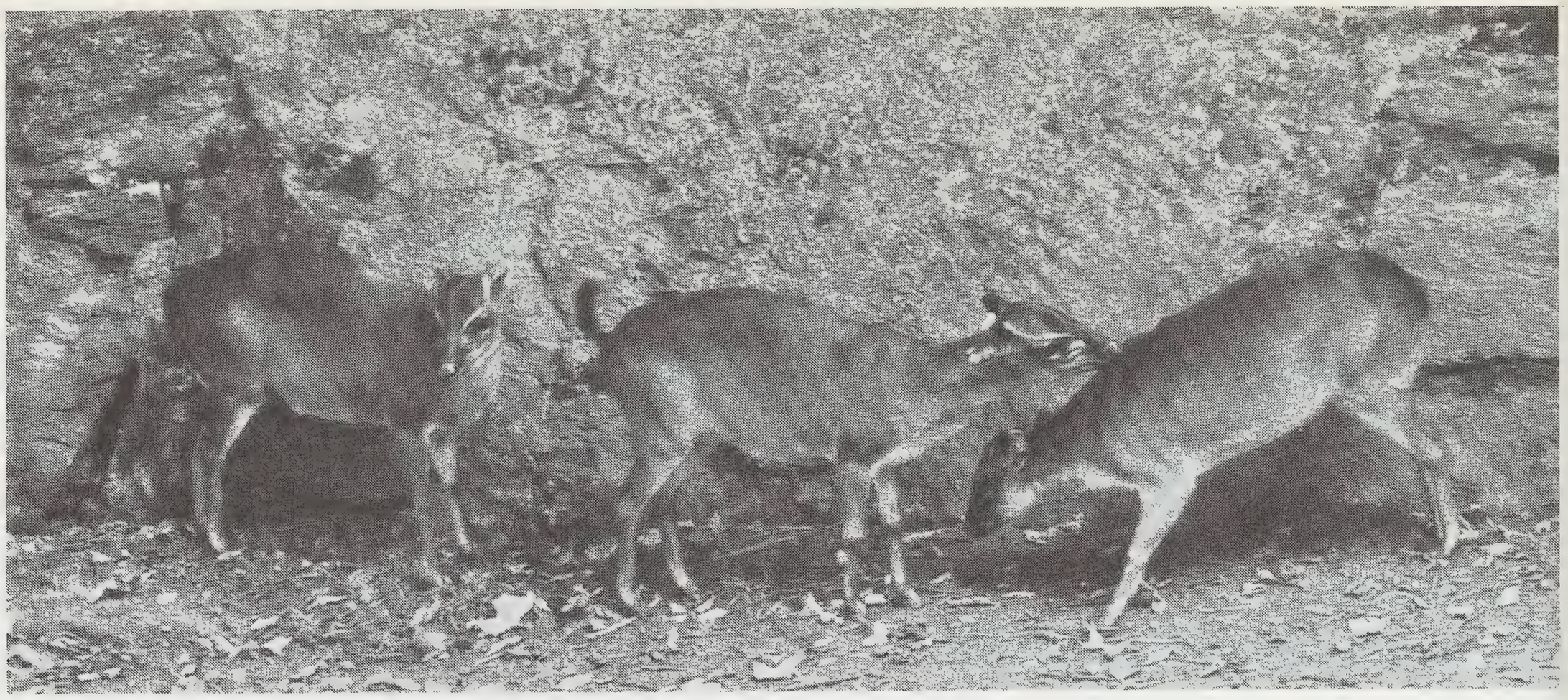
In probably the most ambitious undertaking of its kind, the Bronx Zoo's Department of Exhibition and Graphic Arts, under the direction of Curator Jerry M. Johnson, made giant rubber molds of a Hudson River Palisades cliff face for reproduction as a nesting and resting place as one part of the World of Birds, now being constructed at the zoo.

The cliff face measured about 40 feet wide by 30 feet high. The eventual castings will measure 100 feet in width by an approximate 40 feet in height,

To accomplish the moldmaking, a crew of four men on 30-foot-high ladders brushed 12 successive layers of latex rubber onto the rock face, plus one layer of burlap. To keep the mold from stretching and becoming distorted, a jacket of woven glass fiber was applied to its exterior.

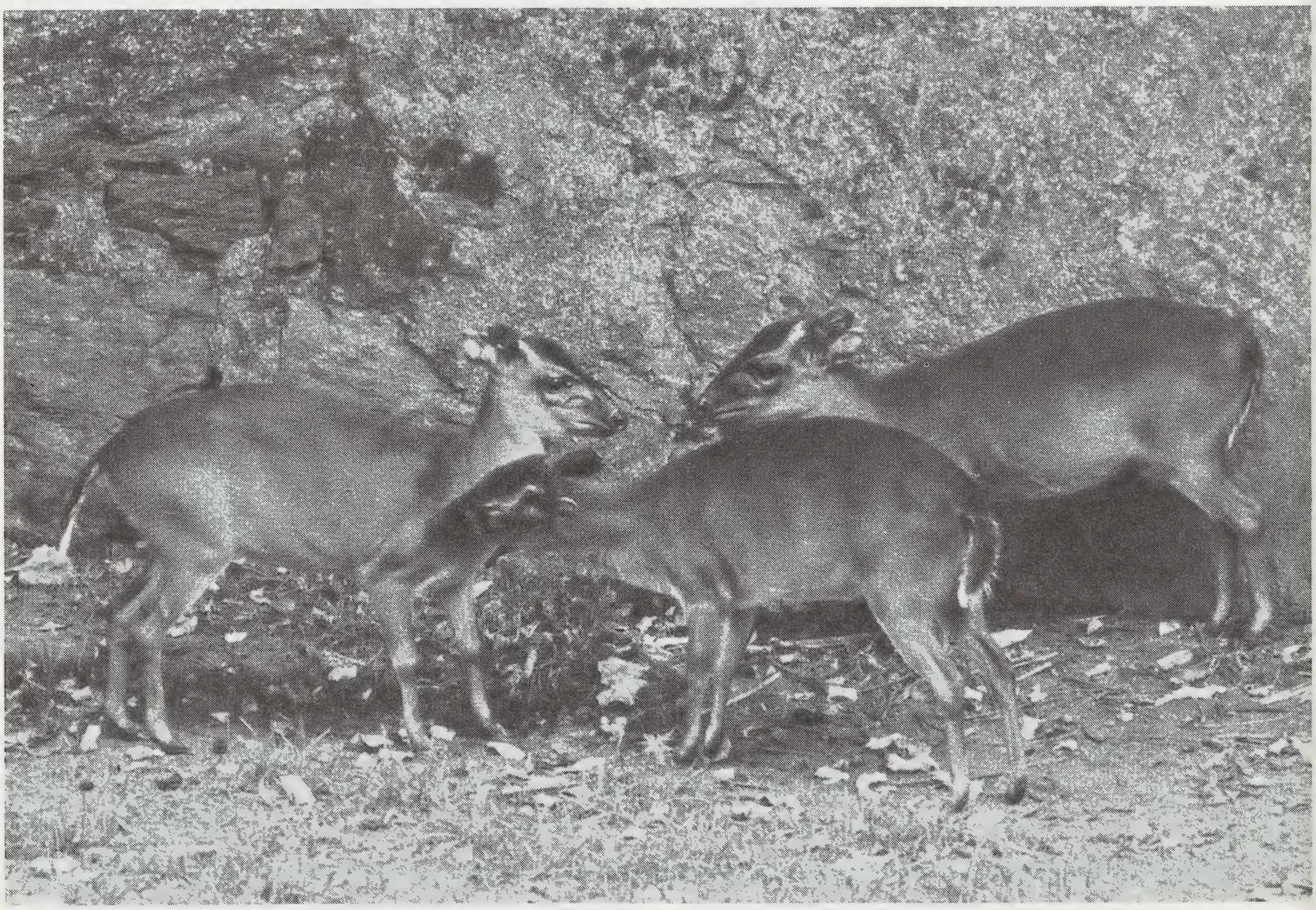
The mold of the cliff face was divided into 32 roughly rectangular sections into which it was cut before it was separated from the rock and transported to the zoo exhibits workshop. There the sections will be assembled into their final configuration and a casting, made of glass fiber and resins, looking as rocklike as the original, will be installed in the World of Birds.





DUIKERS

From African Forests to "African Plains"



Katherine Ralls

When the Dutch settlers arrived in South Africa, they found living there a small antelope that, at the slightest disturbance, would dive into the nearest patch of cover. They named this antelope "duiker" or "duikerbok," which means "diver" or "diving buck," respectively.

Since most duikers live in dense forests where cover is abundant, this habit makes their natural life extremely difficult to observe, and field reports of scientists who study duikers tend to be limited to observations of diving behavior.

In addition to their relatively small size, all duikers have small, spike-like horns (which may be lacking in the female), a naked muzzle, and large glands beneath the eyes. The sexes are identical in coloration, but females are regularly larger and heavier than males.

Scientifically speaking, duikers form the subfamily Cephalophinae of the family Bovidae, a family which includes, in addition to the antelopes, such familiar animals as cows, sheep, goats, and their relatives. The Cephalophinae are divided into two genera: *Sylvicapra,* containing only the gray duiker, *S. grimmia;* and *Cephalophus,* containing approximately 15 species (the exact number is still a matter of dispute among experts).

The gray duiker has the largest area of distribution, and it is in this sense that it also is called the "common" duiker, having been reported from South Africa to Senegal in the west to Ethiopia in the east. In contrast to other duikers, the gray duiker is an inhabitant of savannah and brush country and is often found even in cultivated areas.

Individual species of the forest-dwelling duikers of the genus *Cephalophus* are distributed over areas that are often quite small. The number of species in a given area tends to decrease as one travels toward the east and south of Africa, paralleling the decline of the forest in these directions.

Several natural groups of species occur in this genus. The two smallest species, the blue duiker *(C. monticolus)* and Maxwell's duiker *(C. maxwelli),* both about the size of a fox terrier, are clearly more closely related to each other than they are to the other members of the genus. In fact at one time a separate genus, *Philantomba,* was used to distinguish the blue duiker and Maxwell's duiker from the rest of their kin. The ranges of the two species hardly overlap at all; the blue duiker occurs to the east and south of Nigeria, and Maxwell's duiker inhabits an area from Nigeria west to Senegal. These two species form what biologists call a *superspecies,* that is, a group of two or more closely related species that are geographically isolated from one another. In evolutionary terms, a superspecies was presumably once a single species with two or more easily distinguished subspecies. The subspecies diverged more and more in the course of evolution, until at last they reached the level of separate species.

The three largest duikers also form a natural group. The largest species is the yellow-backed duiker *(C. sylvicultor),* which is about the size of a St. Bernard dog. It has a striking patch of yellow hair beginning at the shoulders and broadening out over the rump to form a triangle. The hairs of this patch can be raised, especially when the animal is alarmed, but its function is unknown. Closely related to the yellow-backed duiker is the little-known Abbott's duiker *(C. spadix),* which is somewhat similar in appearance, but smaller. The third member of this group is Jentink's duiker, *C. jentinki.*

Another group of duikers which may form a superspecies consists of the solid-colored red forest duiker *(C. natalensis);* Peter's duiker *(C. callipygus),* distinguished by a dark dorsal stripe; and *C. adersi,* a species marked by a white hip stripe, found only on Zanzibar Island.

The black-backed duiker *(C. dorsalis),* a handsome chestnut animal with a broad black stripe down the center of the back, is the best known representative of a fourth and final group of duikers. It is one of the most nocturnal duikers. In captivity, the animals are typically found lying down in their enclosure during the day, chewing their cud, or if quite undisturbed, curled up with closed eyes. According to Dr. Thomas Struhsaker of the New York Zoological Society, who encountered this species during his recent field studies on African primates, the black-backed duiker is referred to as the "sleeping deer" by natives in west Cameroon. This indicates that its daytime behavior in captivity probably accurately reflects that in the field. The white-bellied duiker *(C. leucogaster)* is a sort of "washed-out" version of the black-backed and occurs in the same range, while the closely related Ogilby's duiker *(C. ogilbyi)* is found only on Fernando Poo Island, off the coast of Cameroon.

The remaining species, which do not fit into any natural group, are the black duiker *(C. niger),* the black-fronted duiker *(C. nigrifrons),* the red-flanked duiker *(C. rufilatus),* and the zebra duiker *(C. zebra).* The zebra duiker is the most strikingly colored duiker, with a bright orange coat marked

At left and below: the gray duiker of Africa's savannah and bush country. Above: Maxwell's duiker. Note the large scent gland under the eye.

with wide blue-black vertical stripes. It is found only in a limited part of the lowland forest zone in Sierra Leone, Liberia, and the western Ivory Coast.

As far as is known, all duikers normally live individually or in pairs, and do not form larger social groups. Maxwell's duiker, which I have observed at the Bronx Zoo, is an extremely pugnacious species. A male Maxwell's duiker was observed chasing a group of black-backed duikers around a cage, although they were at least twice its size. Three Maxwell's duikers introduced into the African Plains exhibit, a spacious outdoor enclosure already inhabited by a herd of female and young nyala *(Tragelaphus angasi),* at first ignored the larger antelopes. As the days passed, the duikers became more confident, cautiously approaching and sniffing the nyala.

Eventually, one male and one female duiker became consistent nyala chasers, incessantly driving the nyala group. Although they were often bowled head over heels when struck by the legs of the fleeing nyala, the duikers usually jumped up at once and resumed the chase. The sight of a diminutive one-foot high duiker chasing a panicked group of deer-sized nyala would have been quite amusing had it not been for the possibility that some of the animals might be injured. The guilty pair of duikers are now allowed excursions onto the African Plains only when the nyala are confined in their barn or corral.

Maxwell's duikers are especially intolerant of other Maxwell's duikers of the same sex. In captivity, an encounter between two males leads immediately to a brief but vigorous fight. The loser quickly turns and runs wildly, often crashing into familiar fences and making spectacular, almost vertical,leaps of six feet or more in its haste to escape from the pursuing victor.

Meetings between females are only slightly less dramatic. Adult females live peacefully with daughters which have grown up in the same cage, but usually attack females which are not their usual cage-mates. Sometimes a short fight occurs, but more commonly a weaker female runs away almost at once if approached by a stronger female. The stronger female relentlessly pursues the weaker, even in large enclosures.

One of the most conspicuous behavior patterns of Maxwell's duiker is scent marking. The well-developed scent glands used for this purpose are visible in the living animal as large swellings on the sides of the face between the eyes and the muzzle. Both males and females frequently rub the secretion of the gland on protruding objects in their environment, although males mark roughly twice as frequently as females. When kept in cages, duikers mark such objects as water buckets and feeding pans. In more natural outside enclosures, duikers most frequently mark young trees and bushes although they also mark stones and protruding tree roots.

In addition to depositing scent on their environment, a pair of duikers frequently rub their glands together, thus mixing the scent of the male's gland with the scent of the female's gland. If a male is kept with two females, only one of them normally rubs its glands on those of the male and scent marks the environment. The second female performs neither of these activities and is generally kept in an inferior social position. Judging from their behavior in captivity, duikers in the wild probably maintain fixed territories with the boundaries marked by scent marks and from which they drive off other duikers.

Courtship in Maxwell's duikers is less elaborate than in many other antelopes. The male, as in most hoofed animals, regularly examines the urine of the female, apparently determining the sexual condition of the female in some way by its smell or taste. If the female is receptive, the male chases or "drives" her and bites at the root of her tail with such force that her hind feet are often lifted off the ground. Driving gradually subsides into nose-to-tail circling, and mating follows. One calf is born after a gestation period of about four months.

A male and female Maxwell's duiker rub their scent glands together, thus mixing the scent.

A duiker calf receives a minimum of maternal care. It does not follow its mother, but spends most of its time lying alone in a protected spot. It seems to select its own places to hide and searches out its mother when it wants to nurse; a mother duiker does not hide her calf or call it out of hiding to be nursed. When two mother duikers, each with her own calf, were kept in the same cage, each allowed either calf to nurse. The calves in turn showed no discrimination, approaching both mothers with equal frequency. In the wild, a mother duiker would never encounter a strange calf, and hence would have no occasion to distinguish her own calf from others.

Duikers have been thought to feed mainly by browsing on leaves and fruits. Nevertheless, wild duikers have been reported to eat termites and even kill and eat birds. The latter activities have

been observed more closely in black-backed duikers at the Zurich Zoo. F. Kurt reports that pigeons began to disappear mysteriously one by one, and duikers were the only plausible suspects. When offered freshly killed birds, they ate them at once. The "hunting" behavior of the duikers was then observed. When a duiker caught sight of a bird, it pointed its head toward the prey, laid back its ears, sniffed with wide-open nostrils, and approached the bird with lowered head. When the bird attempted to fly, the duiker gave chase. Small birds were killed at once by bites on the breast and stomach, while pigeons on the ground or just taking off were trampled to death. The duiker usually carried the victim in its mouth to its hay pile. Small birds were then eaten completely, while pigeons were eaten piece by piece, the wings and legs being discarded.

Since duikers are so difficult to observe in the wild, records of their behavior in captivity are especially valuable. The behavior of duikers is also of interest because we know from the study of fossils that the ancestors of the living members of the bovid family were somewhat similar in appearance to duikers and lived in similar forest habitats. It is reasonable to expect that not only the appearance and habitat but also the behavior of duikers resembles that of ancestral bovids. For this reason, future increases in our knowledge of duiker behavior may lead to a better understanding of the evolution of behavior throughout the great family of horned animals.

A Maxwell's duiker attempts to rub its scent gland with another. This group of three duikers lives in the African Plains exhibit at the Bronx Zoo. In the wild, duikers usually live individually or in pairs and do not form larger social groups.

DAZZLING DISPLAY

Courtship Assemblies of the Manakins

by Alan Lill

The following grants have provided support for Dr. Lill's research: AF-AFOSR-1254-67 (United States Air Force Office for Scientific Research) and GB-8313 (National Science Foundation).

From my vantage point in the blind high above the forest floor, I could see a faint pink glow above the wooded shoulder of a ridge to the east. The tree-tops all around me were still merely shadowy outlines when, from 40 or 50 feet away, I heard the first soft *pu* call, indicating that day had also begun for the golden-headed manakins. One by one in the half-light, the small birds took up their accustomed perches in the trees around me. As the light improved, the simple beauty of the assembled males was revealed: the jet-black body plumage strikingly contrasted with the golden cap, white eyes, and pale yellow beak.

The calls became more frequent. Soon one male flew up and away from the assembly to perch high in a tree-top 50 feet away. After uttering two or three plaintive notes, it swooped rapidly, calling as it dove. With a final upward, then downward, swoop to complete its parabolic path, the male landed on a perch and gave a loud, buzzing call. In a continuum of movement, it backed along the perch with paces so small and rapid that it appeared to be sliding. Slowly it raised both wings high above its back, revealing the striking red-and-white feathers of the upper legs. This was the first display flight, the beginning of a ritual that would continue until the light began to fade in the late afternoon, a ritual that takes place daily for much of the year in the rain forests of the island of Trinidad.

The manakins (family Pipridae) are small, sturdy birds related to the cotingas and tyrant-flycatchers. The family comprises nearly 60 species of forest-dwelling birds and is neotropicopolitan in distribution. Fruits form the largest part of the manakin diet, but these birds also

At right: the white-bearded manakin.

consume small amounts of insect matter. Their nests are simple "hammocks" or "cups" made of plant stems and slung at varying heights in the forks of saplings, trees, or fern fronds. Most species of manakins are sexually dimorphic. The males have either strongly contrasting colors or markings of brilliant blue, red, or yellow feathers, while the females are a drab, cryptic green.

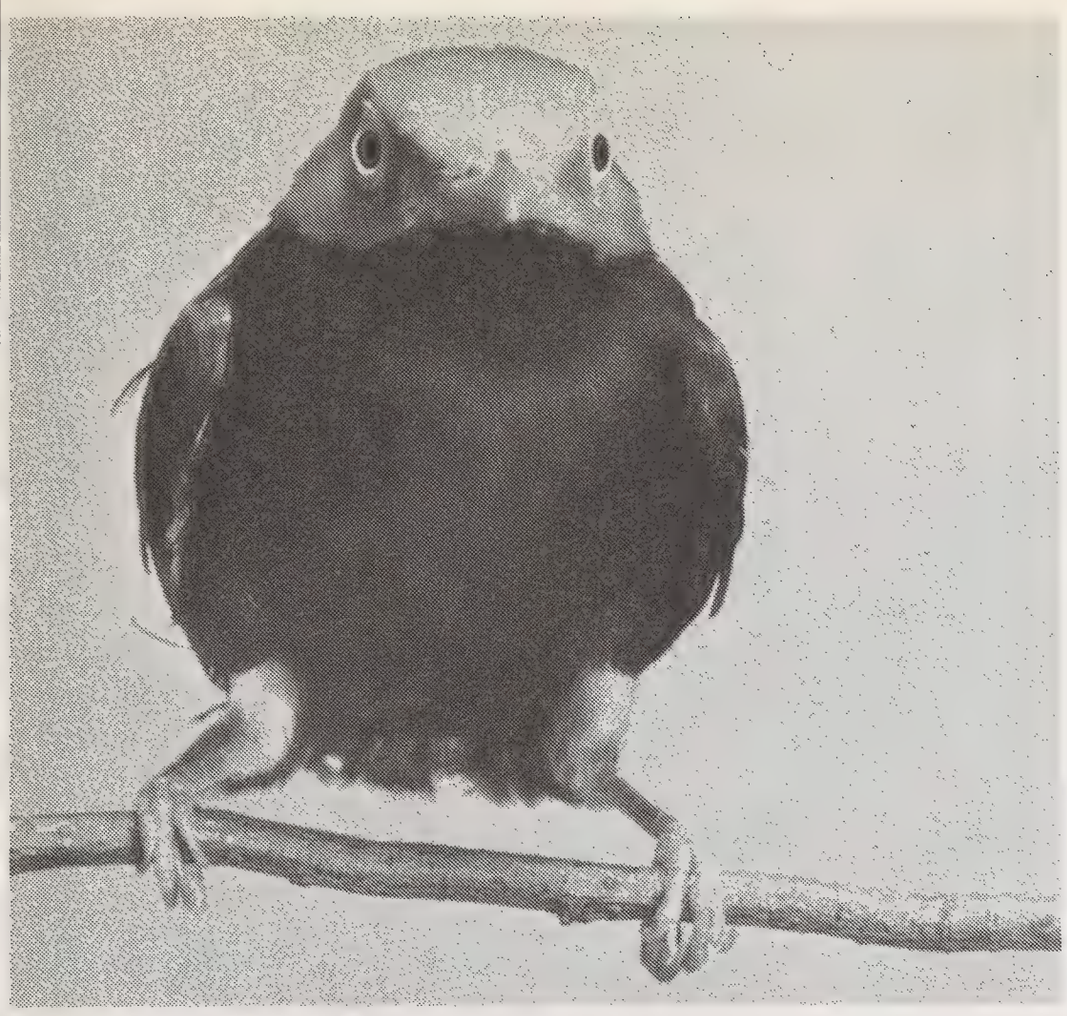
The courtship behavior of manakins is dramatic and has attracted considerable scientific interest. In several species, displaying males make startling, mechanically-produced sounds. The display of the white-bearded manakin, for example, is accompanied by snaps, cracks, grunts, and whirring sounds which are made by the movement of specialized wing feathers and which make the whole performance sound more like a fireworks exhibit than a courtship ceremony. The club-winged manakin has specialized secondary feathers with which it makes mechanical "clicks" and "buzzes" as the wings are raised and lowered in display.

The displays include acrobatic and spectacular movements. In the genus *Manacus,* the displaying male jumps between saplings and rotates in mid-air to face the perch which it has left. The performance is accompanied by mechanical sound production. Some manakins have evolved slow, hovering displays, while males of the genus *Pipra* perform elaborate display flights, "sliding" on perches and vibrating the body. The pintailed manakin loops-the-loop; the fiery-capped manakin hangs upside down and rotates from side to side; pairs of blue-backed manakins perform a synchronized cartwheel dance together; and the white-ruffed manakin crawls along a log in a slow, undulating manner with wings spread. A number of secondary sexual structures are shown off in manakin displays. These include stiffened head feathers, erectile crests, "horns" and beards, and in the wire-tailed manakin, long, wire-like tail feathers.

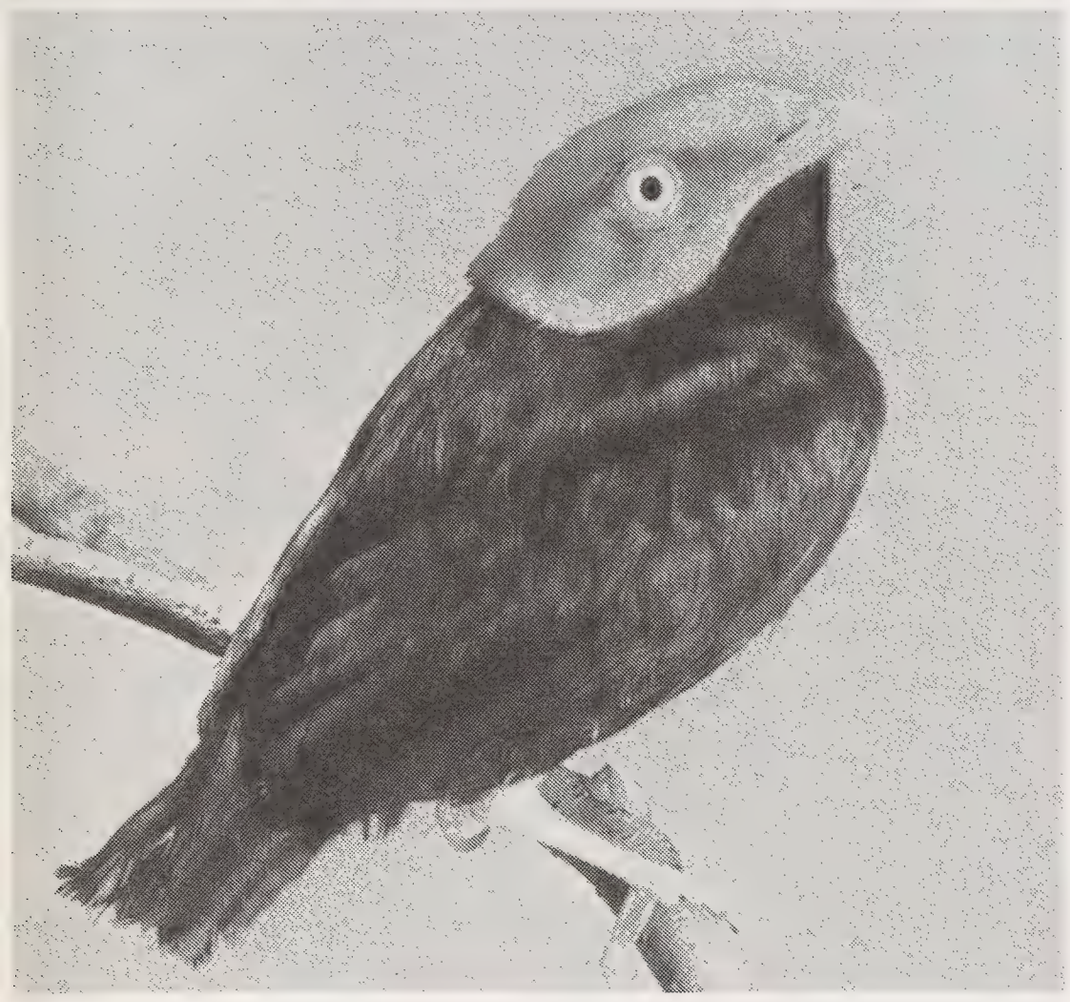
These striking courtship performances are rendered even more spectacular in many species by the tendency of males to display in groups at traditional sites in the forest. This phenomenon, known as lek display (supposedly from the Swedish *leka* = to play), has been discovered in other families of birds and even in some antelope and fruit-flies. The display ground is a mating arena where males display to attract females. In lek species, males are promiscuous and polygamous, and the females carry out all parental duties. In manakins, communal courtship may involve as few as two males or as many as 50 or 60 in different species.

Since 1967, part of my time has been spent studying the leks of the white-bearded manakin (*Manacus manacus*) and the golden-headed manakin *(Pipra erythrocephala)* at the New York Zoological Society's Tropical Research Station in Trinidad. Dr. David Snow, an English ornithologist, had already studied the basic ecology and breeding biology of these birds at the station between 1956 and 1961, but I wanted to study in detail the socio-dynamics of leks in these manakins in relation to avian evolution and survival value of group display at fixed, traditional sites.

White-bearded manakins have terrestrial leks. The black-and-white patterned males clear courts around their display saplings by stripping the



The golden-headed manakin (above and below) was studied from a tree blind about 50 feet above the ground in the forests of northern Trinidad (at left). The author has spent hundreds of hours on such platforms studying the courtship behavior of the assembled males.



group of dead leaves so as to leave an oval patch of bare soil, which contrasts markedly with the surrounding leaf litter.

On and above these courts, the males jump and posture in display, producing as they do so the odd mechanical sounds described earlier. Assemblies may have from six to 60 males and their performance can often be heard from 60 to 70 feet away. Golden-headed manakin males display in groups of four to 16 males about 20 to 60 feet up in the forest canopy. Each adult male has his own perch and also tends to strip away the surrounding leaves to create a sort of arboreal court. On their perches the males perform display flights, jumps, and slides, accompanied by vocally-produced sounds. In both species, cryptically-colored females visit the leks in the early morning and middle of the day to display and to mate with the assembled males, but when display is slack, the males meet in ritualized aggressive encounters which occasionally erupt into vicious fights.

In order to understand the social relationships of these birds properly, I color-banded individuals caught in nets at feeding and bathing sites. To date I have marked 700 manakins in the small mountain valley which forms my study area. To my surprise, I soon began to catch manakins and other birds, some of which were 10 or 11 years old, which had been banded by Dr. Snow. This is a remarkable age when compared with the life-span of similarly-sized birds of temperate latitudes.

I have spent hundreds of hours at the manakin arenas in order to get a complete picture of the social organization of leks. Much of the time is spent in blinds systematically recording behavior, but the five-month-long breeding season seems to drag at times. Fortunately the forest had other attractions to offer the hidden, silent observer when display is at a low level. Agouti often gamboled around the blind at the white-bearded manakin leks, a mongoose occasionally slunk quietly by, and tegu lizards foraged noisily in the brush. Deer and ocelot were rarer visitors, but tayra often crossed the arena, bounding up the nearest tree with angry barks if they spotted me. Snakes were common if slightly less welcome intruders, and fer-de-lance seemed especially interested in the blind and sometimes made uncomfortably close inspections.

Up in the tree blinds 50 feet above the forest floor at the leks of the golden-headed manakins, which I am now studying, I found myself in a world of birds hitherto only occasionally glimpsed from ground level. Toucans, bellbirds, trogons, tityras, and cuckoos were my daily companions, and richly colored honeycreepers and tanagers fed all around me. This past season, a cocoa thrush selected one of my tree blinds as a nesting site, and we sat there three feet apart, separated only by a piece of burlap, each silently pursuing our different "objectives." The wet season brought a different kind of diversion, as rotten trees and dry bamboos crashed about the blinds during torrential rain storms and the tree platform swayed alarmingly with every gust of wind.

I have been able to distinguish three categories of males at the arenas of both species of manakin. Resident males in full adult plumage defend territories around their courts or perches, on which they are usually dominant to all other

"Courts" are cleared by the male white-bearded manakins at their arenas by stripping the forest floor of its carpet of dead leaves. As the males display on and over these courts, they produce startling mechanical sounds.

males. But a newly established white-bearded manakin male may be subordinant to some of its neighbors even on its own territory and will regularly be driven off its court. However, as soon as a female lands on the male's court, these attacks by neighboring males are inhibited and courtship proceeds unhindered.

Golden-headed manakin males, on the other hand, regularly invade neighbors' territories during female visits, and often disrupt courtship and mating. Intruder males have adult plumage but not established territories at the arena, and they display randomly around the lek; they seem to be both new males attempting to infiltrate the system and old "drop-outs" which have lost their residential status. Young males in female-type plumage also pay brief visits, often in small groups, to the arena and display with the resident males. Although resident males are continually meeting in aggressive encounters, there is no overall dominance hierarchy amongst the group.

Some males in the competitive lek systems of the white-bearded manakin and golden-headed manakin were outstandingly successful in attracting females to their territories and mating with them. However, the majority of males in a display group, especially the white-bearded manakin, made little contribution to the overall mating level and were in effect reproductively redundant. My observations on color-banded females of both species showed that the majority mated only with a single male.

Although golden-headed manakin females quite often visited more than one arena in a day, I saw only one that mated at two arenas in a single season. Even those golden-headed females which are faithful to a single male throughout a season may show only short-lived fidelity – the few banded females that I have seen mate in two successive seasons mated with different males at different arenas in each season.

What are the factors affecting a male's success in attracting females? This has proved to be one of the hardest questions to answer. At some golden-headed manakin arenas, females generally select males in the more crowded center rather than those isolated on the periphery. Possibly this is because the level of stimulation is higher in the center. Not all central males, however, are popular, and many factors clearly must affect mate choice.

Dr. Lill holds an adult male white-bearded manakin caught in mist nets at a feeding site. Color-banding of trapped birds enabled him to recognize individuals subsequently at the arenas where they displayed and thus to interpret the social organization of the leks more fully.

It appears that the size of male courts and territories in the white-bearded manakin are unimportant in determining popularity of the males with females, and that the small size variations among the males also appear insignificant in this respect. Possibly the most aggressive males or those which display most are more successful. Females often come to the arena in small groups, especially early in the season, and I could see that the movements of one female had a pronounced affect on those of others in the group. This may be another factor influencing mate selection.

In the majority of bird species which have lek systems, sexual dimorphism is very pronounced, courtship display is spectacular, and males often have secondary sexual structures which play an important role in courtship. Charles Darwin, more than one hundred years ago, first recognized that the evolution of extreme sexual dimorphism of this kind occurred through the process of sexual selection: males freed from the burdens of parental behavior and duties compete strongly to attract mates, and any character which facilitates such attraction acquires selective advantage and spreads through the population. The mating habits of the manakins show this process in action in dramatic fashion. The kind of unequal distribution of mating which I have found in the manakins may also be important in determining the rate of evolution within populations and possibly also exerts an affect on population density.

Perhaps too little is understood about lek systems to appreciate exactly why it is advantageous for the individuals of some species to display in groups at fixed, traditional sites and apparently not so for other closely-related species. I have found that large golden-headed manakin leks attract females to about the same extent as small ones, but many more matings occur at the larger arenas. Thus it seems that larger groups of males are really more stimulating for the females in this species, and this may be a partial answer to the enigma of group display.

Only a handful of the many species of manakins have been studied in any detail. Such studies have provided glimpses of complex courtship displays and social systems, but the manakins have many more surprises to offer to the patient observer who is prepared to be a silent witness to their forest rituals.

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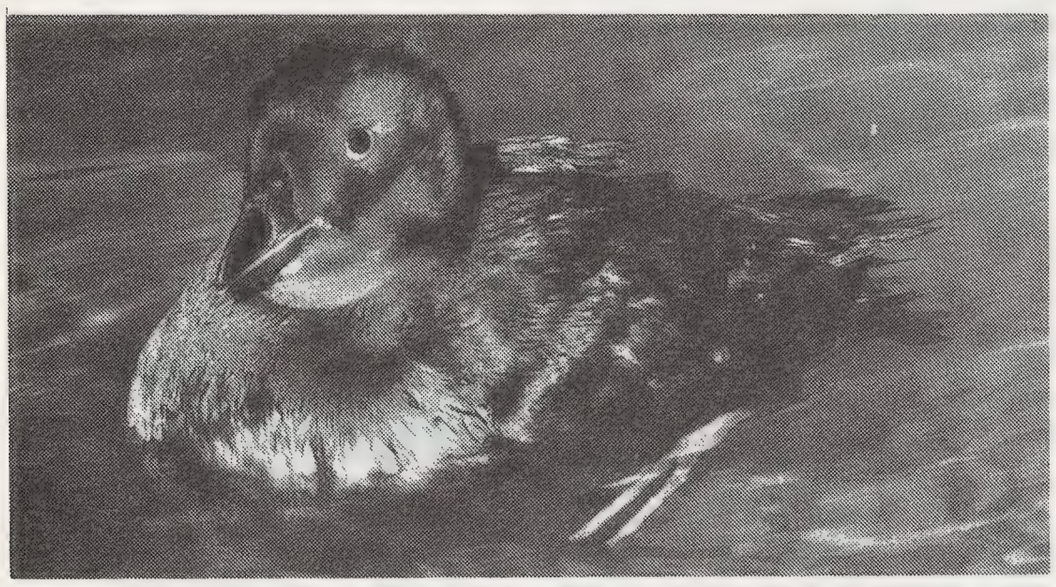

The first tufted puffin chick to be bred in captivity swims in a specially-refrigerated room in the Aquatic Birds Building at the Bronx Zoo.

Coldwater Puffin and Hot Weather Brush Turkeys Hatch at Bronx Zoo

A tufted puffin, first ever hatched in captivity, is swimming around in a specially-cooled room at the Bronx Zoo, while in another part of the zoo, brush turkey chicks are on their own after hatching in a mound of naturally-heated vegetation. The puffin is a bird of the cold waters of the Northwest Pacific. Brush turkeys live in the scorching hot Australian outback.

The tufted puffin chick emerged September 15 from its burrow, where it had hatched some 50 days earlier, and dove into the cold (57°F.) waters of its sea cliffs home in the Bronx Zoo's Aquatic Birds Building. It became the first member of its species – indeed, the first member of the entire family of sea birds known as alcids – to be bred in captivity, anywhere in the world.

Two days later, on September 17, a brush turkey chick hatched inside a large nest-mound of warm, fermenting vegetation (over 90°F.) and, laying on its back, dug itself out with its strong feet, the first member of its species to be bred at the Bronx Zoo. Since then five more brush turkey chicks have hatched in this unique manner.

Brush turkeys belong to a family known as megapodes (meaning "big feet") of Australia, New Guinea, and East Indian islands. Members of this family are the only birds whose eggs are not incubated by body heat but by the heat of the sun, by fermentation of vegetable material, or by volcanic action, depending on the species.

The male brush turkey builds a large mound of vegetation, sometimes up to 10 feet tall, where the female deposits from 10 to 30 eggs, the small end down, at a depth of about two feet. The liberated female then departs, leaving the upkeep of the large natural incubator to the male. The male continues to work on the mound, often digging a hole and inserting his beak inside to test for the proper temperature. But even he is long gone before the chicks hatch inside and dig their way out. The chicks are able to fly and feed on their own as soon as they emerge. This species has been bred extensively in Europe and also at the St. Louis Zoo and San Diego Zoo.

Tufted puffins, however, are rarely maintained in captivity. In the wild, they spend most of their life at sea, coming ashore only to nest in vast colonies along the Pacific coast of Alaska south to Canada. In captivity, they must be kept in refrigerated quarters with plenty of fresh moving water. Such an exhibit was built for tufted puffins, and other members of the alcid family, in the zoo's Aquatic Birds Building which opened in 1964.

Puffins nest in burrows which they dig themselves among the rocky cliffs. (In the Aquatic Birds Building, the fiberglass burrow was made for them by the zoo's Department of Exhibition and Graphic Arts.) One egg is usual, and after the chick hatches, it stays in the burrow where it is fed by the parents for about 50 days before emerging on its own. Eggs were laid in 1968 and 1969, but failed to hatch.

The tufted puffin chick is nearly the same size as its parents but lacks the colorful bill and long white plumes, or "tufts," behind the eyes that characterize the adults.

Sharp-toothed Baby Piranhas Are Hatched for First Time at New York Aquarium

For the first time in the history of the New York Aquarium, baby piranhas have been hatched and are being raised successfully – so successfully, in fact, that the young number at least 700.

Tended by Werner Schreiner, a menagerie keeper at the aquarium, the new babies are the products of four hatchings, the first of which occurred in June of this year. These hatchings were obtained from 12 spawnings of a pair of black piranhas in a tank in the aquarium's main exhibit hall. In each spawning, the eggs were deposited in the lower left-hand corner of the tank.

The eggs were removed from the exhibit tank and the hatching occurred in a 20-gallon tank in the aquarium's holding area. The parent piranhas are still breeding.

The piranha, a native of the Amazon River in northern South America, has a deserved reputation as a voracious carnivore. The teeth of piranhas are short, strong and razor-sharp and so arranged that they snip off pieces of flesh from the bodies of prey, both living and dead. Piranhas travel in large schools and will attack any living animal they encounter, soon reducing their victims, including cattle and human beings, to bare skeletons.

Giant Galapagos Tortoises Shipped to Honolulu in Conservation Effort

Five giant Galapagos tortoises were shipped from the Bronx Zoo to the Honolulu Zoo Tuesday, October 6, as part of an effort to breed the rare creatures. A sixth giant tortoise, which was collected in the Galapagos Islands in 1928, will be returned to the islands, where it will be added to the tortoise breeding population at a research station. The date for the shipment of this tortoise has not been set.

The Honolulu Zoo has been the most successful zoo in the world in breeding the giant tortoises, which are considered by zoologists to be an endangered species. So far this year, 15 tortoises have been hatched from eggs laid by one female in the Honolulu Zoo's collection.

The tortoises bound for Hawaii and the single animal that will be sent to the Galapagos constitute the entire collection of these animals at the Bronx Zoo. All are female.

The lack of a male tortoise and of the larger quarters needed for breeding the tortoises prompted the Bronx Zoo to send its animals to Hawaii and the Galapagos. "Eventually we will have a breeding facility and at that time, under the terms of our agreement with the Honolulu Zoo, we will obtain some young tortoises from Hawaii," said Dr. F. Wayne King, curator of herpetology at the Bronx Zoo.

Arrangements will be made shortly for the shipment to the Galapagos Islands. The tortoise will be added to a collection of the giant reptiles maintained on Indefatigable Island in the Galapagos archipelago by the Charles Darwin Research Station, which is under the auspices of UNESCO. Scientists at the station have had considerable success in breeding the tortoises and restocking them on their native islands.

New York Aquarium Exhibits Sea Snakes

A pair of banded sea snakes has been placed on exhibition in the main hall of the New York Aquarium at Coney Island. Sea snakes are the only living sea serpents whose existence is a scientific certainty. Several different kinds of sea snakes live in the Indo-Pacific area.

The aquarium's snakes, which were donated by Arthur Heine of Marine Tropical Imports, were captured off the Philippine Islands. Each of the snakes is about three feet long, and marked with bands of grey and black. All sea snakes have venomous bites capable of causing death in humans. However, most of them are not particularly aggressive.

Sea snakes are often found near estuaries and sometimes swim for long distances up rivers. They also are common near islands and coral reefs. However, great bands of sea snakes have been sighted far from land, sometimes basking at the surface or swimming with their heads out of water. These animals, as reptiles, breathe atmospheric air, but they can remain underwater for as long as a half-hour.

The tail of the sea snake is flattened vertically in a shape that is oarlike, an adaptation that permits efficiency in swimming. When grounded, most sea snakes are relatively helpless, but the banded sea snake can travel overland and lays its eggs on coral reefs.

THE bookshelf

INSIDE THE ZOO. *By Morris Weeks, Jr. 96 pp. Simon and Schuster, New York. 1970. $4.29.*

"What goes on behind the bars in a zoo?" asks the promotion blurb of this new book for young people. On the cover of the jacket, a tiger is depicted behind a design simulating the bars of a cage. Before you begin to read the book, there is enough emphasis on bars to make a zoo man cringe.

Bars – they are what today's zoos are trying to get away from. You cannot blame the book jacket on the author, but it is too bad that one's first impression of the book is that it improperly represents modern zoo philosophy. This is especially unfortunate because Mr. Weeks, in his account of behind-the-scenes at the Philadelphia Zoo, shows an excellent grasp of what is happening in zoos today. His book contains a substantial amount of solidly factual material, from the constituents of animal diets to what zoos paid for lions in 1874.

However, the writing style is unexciting and most of the black-and-white photographs are uninspiring – some of them, in fact, are of poor quality.

Inside the Zoo probably suffices as a book of information for confirmed zoo buffs, but as a vehicle calculated to interest youngsters in zoos, its value may prove questionable.

E.R.R.

THE WORLD OF BATS. *Photographs by Nina Leen. Text by Alvin Novick. Holt, Rinehart and Winston, New York, 1969. $23.95.*

BATS OF AMERICA. *By Roger W. Barbour and Wayne H. Davis. The University Press of Kentucky, Lexington, 1969. $17.50.*

There is an "immense and obscure domain" that has recently been explored by two probing and revealing books. Here is a world of creatures so numerous, so diverse, and so intimately associated with us – and so fascinating – about which we know so little. If we are at all aware of bats, it is through an extensive and misleading folklore, or possibly a rare and unrevealing glimpse of something momentarily seen in obscuring dusk. Their domain still remains a largely unknown realm, but we at last can begin to know the bats.

The World of Bats by Alvin Novick with superb photographs by Nina Leen does, indeed, introduce us to this world. A large number of species from around the world are portrayed in actions and backgrounds that reveal much about their natural history. Dr. Novick's text conveys the scientific knowledge in a forthright and readable manner, and includes the vast areas in bat natural history where knowledge is lacking. No one can come away from this book without enrichment.

Bats of America is every bit as stimulating even if narrower in scope. All forty different species of bats found in the United States are figured in color and black-and-white photographs. The photographs are excellent and diagnostic. There is a species account of each which discusses the known biology. An illustrated key to the species is included which should be definitive.

Unfortunately, both volumes are expensive. But, at least make sure that your library obtains them and that you read them, for these two books on bats bring into our grasp a rich and illuminating experience.

Hugh B. House

ABOUT THE authors

John L. Behler, Jr., is a herpetologist at the Bronx Zoo. **William G. Conway** is general director of the New York Zoological Society. **U. Erich Friese**, former assistant curator at the New York Aquarium, is curator of fishes at the Taronga Park Zoo in Sydney, Australia. **Alan Lill** is a member of the staff of the Institute for Research in Animal Behavior. **Katherine Ralls** is associate curator of education for the New York Zoological Society.

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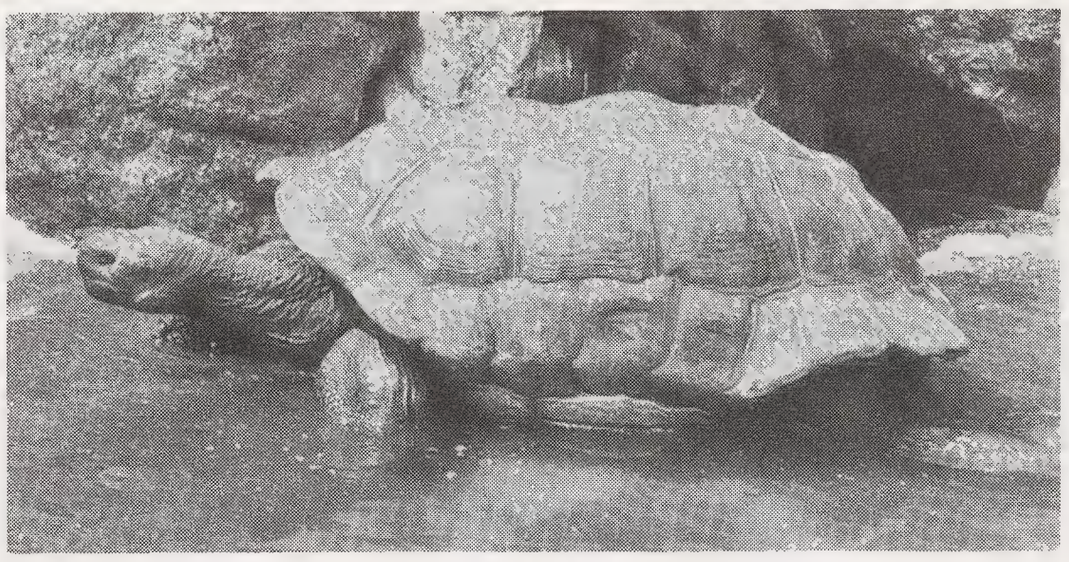
DYING SPECIES...

"The beauty and genius of a work of art may be reconceived though its first material expression be destroyed; a vanished harmony may yet again inspire the composer; but when the last individual of a race of living things breathes no more, another heaven and another earth must pass before such a one can be again."

William Beebe
First curator of birds, Bronx Zoo

Galapagos Tortoise

Geochelone elephantopus



The Galapagos Islands were first encountered by western man in the 16th century, when a Spanish ship was carried there by the Humboldt Current. The islands, appropriately named the "isles of the tortoises," form an archipelago in the Pacific 600 miles west of Ecuador. Early explorers and buccaneers visiting the islands to refurbish their supplies of wood and water were astonished by the seemingly endless number of tortoises they found there. These animals represented an ideal source of fresh meat and oil, and consequently ships usually left the Galapagos with holds full of live tortoises.

During the 19th century, whaling fleets made the islands a regular port of call and further drained the tortoise population. Hunting by the ships' crews usually was limited to the coastal areas and by the end of the 19th century, the relatively few remaining tortoises were restricted to inaccesible inland regions.

By this time, settlers had established themselves on several of the larger islands. Not only did their hunting pose a continued threat to the remaining tortoises, but the domestic animals they brought with them escaped to the wild and upset the ecology of the archipelago. On several of the islands goats and burros have destroyed much of the vegetation on which the tortoises feed. On other islands, pigs and rats feed on tortoise eggs and hatchlings, while feral dogs and cats harass the adults.

Originally, 10 of the 15 subspecies of the Galapagos tortoise, *Geochelone elephantopus,* were isolated on as many separate islands—Indefatigable, Duncan, James, Chatham, Hood, Abingdon, Narborough, Jarvis, Charles, and Barrington. The remaining five forms occupied the five principal mountains of Albermale Island. Present knowledgy indicates that 10 of these subspecies remain while those forms on Abingdon, Jarvis, Narborough, Charles, and Barrington Islands are believed extinct.

In 1936, a dozen of the islands were designated as national parks by Ecuadorian law and the giant tortoises were given protection. Nevertheless, the tortoises still fell prey to local residents and illegal collectors, as well as to alien mammal predators.

Marking the centenary of Darwin's *Origin of Species,* in 1959 the Charles Darwin Research Station was established on Indefatigable Island. In the years that have followed, the CDRS has taken dramatic steps to conserve the Galapagos tortoise. Law enforcement programs are reducing poaching and collecting activities. Settlers are being informed of the uniqueness of the giant tortoises and their precarious situation. Wardens are now employed to rid tortoise breeding areas of introduced pests.

CDRS personnel have undertaken an exhaustive censusing and breeding program. Members from each of the existing 10 subspecies of *Geochelone elephantopus* have been marked and an accurate evaluation of their status can now be made. The censusing program has shown that several forms which were believed extinct still survive. On Duncan Island, for example, investigators observed that suitable nesting areas were overrun with rats, and although a small population of adults were encountered, no juveniles were found. To ensure the survival of this form, eggs are now being returned to the station for incubation. The hatchlings are reared in protection until they are large enough to cope with Duncan's unnatural predators. Then the young reptiles are placed on the island. This measure, coupled with the station's breeding program, has resulted in a doubling of the world's population of the Duncan Island tortoise.

There is hope for the survival of the Galapagos tortoise if research continues and there is a strong effort to end the drain on existing populations.

JOHN L. BEHLER, JR.

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ABOUT THE COVER

Front: Alaskan moose *(Alces alces gigas),* Major, the herd bull at the Milwaukee Zoo, believed to be the largest moose in captivity, weighs an estimated 1,500 pounds and stands almost 7 feet at the shoulder. For more on "Milwaukee's Moose," see page 2.

Back: Yellowhead jawfish *(Opistognathus aurifrons),* from the West Indies, measures three-and-one-half inches long; its most usual posture is diagonally vertical as it holds its position over the burrow it has excavated in the sand.

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...'s moose

by Alicia Armstrong

Duke, the moose, crossed a shallow stream that feeds into Moose Lake. Then, without pausing, he walked straight into the woods. George Speidel, director of the Milwaukee County Zoo, watched him go. It was something he had wanted to do for a long time – return a moose to the wild. It brought a dream full circle.

Almost 20 years earlier, Mr. Speidel, with the backing of the Zoological Society of Milwaukee County, bought two young moose in Canada and trucked them to the Milwaukee Zoo, then located in the city's Washington Park. When a reporter covering the story for a Milwaukee newspaper saw those four-month-old-calves, he shook his head. "Good grief, George," the reporter said, "are these what all the fuss has been about – these shaggy, long legged things?"

The calves didn't look like much then. They were healthy and sleek, but a moose achieves majesty only with maturity. Then, this largest of the deer is awesome. And when a bull moose stands, alone and still, huge antlers dark against the sky, he is a sight that those who see it always remember.

There had been fuss and would continue to be fuss – years and years of fuss – over Milwaukee's moose and their descendants. Zoos had found it almost impossible to keep moose. They faded in captivity, and no one knew why.

Finally, after years of the most patient observations and intensive care, the Milwaukee Zoo produced a small, healthy, stable moose herd. The Milwaukee Zoo has been the most successful zoo in the world in the keeping and breeding of moose, and although this zoo is admired for many things, Mr. Speidel tells his visitors: "We specialize in moose."

Because moose are so big and bulky, they appear to be hardy. One naturalist once said they gave the impression of "irresistible power." In some respects however, moose actually can be rather delicate. In captivity, for instance, they seem to be prone to intestinal irregularities.

Christie and Harriet, the Adam and Eve of the Milwaukee moose herd, seemed rather spiritless when they arrived at the zoo in September 1951.

The Milwaukee Zoo moose herd consists of Major, the herd bull; a young bull named Loren; twin bull calves; and two adult cows. The moose share their yard with, among others, several mule deer, migrating mallard ducks, Canada geese, and a band of wild turkeys.

Whereas in the wild they had wandered about most of the day, browsing on trees and other plants, in Milwaukee, where food was provided them, they suddenly were so listless that they would not rouse themselves even to eat. In order to make them eat, zoo men made loud noises, shook branches, and shoved the calves.

When someone else provides the groceries, it appears, moose can be very lazy animals.However, Harriet and Christie's excessive indolence probably was due to the abrupt change and re-ordering of their lives.

In many areas where moose once were abundant, the sighting of one of these majestic animals is a truly unusual event. Often, however, the rare wanderer promptly is shot on sight.

C. R. Grondahl, leader of game investigations for the North Dakota Game and Fish Department, says that the occasional moose that roams into his state from Minnesota or one of the Canadian provinces always seems to meet with some accident. "The last I recall," he says, "was harassed by curious people until it succumbed from exhaustion."

Most of the moose deaths in the wild fall into predictable categories, of course. The moose's predators are, in addition to man, the wolf and the bear. Moose like to be in and around water, and apparently a rather large number drown — calves as well as adult moose which fall through thin ice.

Some moose die in forest fires, and many are killed by trains and automobiles.

Moose also are highly susceptible to parasites. *Pneumostrongylus tenuis* (brain worm), a common parasite of white-tailed deer, kills moose, thus it is often hard for moose to co-exist with their smaller relatives. Parasites have never been a serious problem to moose at the Milwaukee Zoo, but they always are considered a potential threat.

Major, the present herd bull of the Milwaukee moose herd, is believed to be the largest moose in captivity. He weighs an estimated 1,500 pounds and stands almost 7 feet at his humped shoulder.

In the fall of 1966, Major developed an abcess under his left antler. The infection spread, affecting his brain, and it was feared for a time that he would die. His weight dropped sharply, and, losing co-ordination, he stumbled as if blind. He was panicked by even the slightest disturbance or unexpected noise. However, Major recovered after huge doses of antibiotics were administered to him by means of the special guns used by zoo men to inject medication into large creatures from a distance. The recovery was especially gratifying, for it showed that the Milwaukee Zoo not only could keep moose under ordinary circumstances but also could maintain a bull healthy enough to survive a critical illness.

One of the biggest factors in Milwaukee's moose-keeping success is diet. Plenty of browse is made available at all times.

When moose calves Harriet and Christie arrived in Milwaukee 20 years ago, Mr. Speidel was their only grocer. To provide them with browse, he roamed the park early each morning, gathering tender branches from a variety of trees. Now, browse is obtained from the Milwaukee city and county forestry departments and from private individuals. Tree cutters tell their customers about the zoo's needs. And it's June in January as far as browse is concerned. Each year, tons of browse are packed in cardboard boxes, frozen, and stored in a Milwaukee cold storage company's freezers. Thus, even when the ground is covered with snow, the moose have their greens. (In the wild, balsam fir is an important winter moose food.)

The Milwaukee moose herd (Major, the herd bull; a young bull named Loren; twin bull calves; and two adult cows) eat about 15 tons of browse in a year. In addition, they are fed diet supplements, including commercial moose pellets, which are high in vitamins and minerals, and carrots, mangels, boiled potatoes, beets, apples, bananas, bread, and oats.

Milwaukee's moose also dunk their heads to snag plants which grow on the bottom of their pond, and they nibble on patches of alfalfa and other vegetation that grow in their two-and-one-half acre yard. These snacks apparently are important to the herd's well being, but Milwaukee zoo men had to learn that the hard way.

Two years ago, it was decided that the grass in the moose yard should be cut regularly so that the yard would look just as tidy as the rest of the zoo. It did. However, the moose did not continue to prosper. They lost weight and became very listless. Zoo men were puzzled, and they cast about for a reason for the herd's decline. They discovered that only one factor had changed – the condition of the yard itself. Perhaps, the zoo staff reasoned, the moose had found some tonic, some beneficial ingredients, as they nibbled the vegetation in their backyard. And perhaps they were just generally happier in unmanicured surroundings. So grass cutting was stopped and the moose rallied.

"If you want to keep moose, don't mow the lawn," Mr. Speidel says. "Moose don't like a nicely trimmed environment."

The moose yard no longer is as tidy as a golf-course fairway; it looks natural again – wild and woodsy. Situated only about 200 yards from a freeway, it is like an open area in the wilds of northern Wisconsin.

Since moose seem to consume browse as rapidly as a vacuum cleaner inhales dust, Mr. Speidel once thought that he eventually might have to give up the moose. It did not seem possible that the browse supply would continue to be adequate, especially since trees sprayed with pesticides could not be used. However, Gordon Z. Rayner, Milwaukee city forester, said his department could provide the moose with "browse for eternity." He said that more than 20,000 unsprayed maple trees in Milwaukee were pruned each year and that "we use three, four, or five thousand trees for zoo browse."

Moose are good swimmers, and the Milwaukee herd delights in a large pond (about 95 feet long, 45 feet wide, and some 10 feet deep in the middle). Also, on warm days, the animals like to sit under or near a water spray on the pond's edge.

The moose share their bit of wilderness with several mule deer, migrating mallard ducks, Canada geese, and a band of wild turkeys. Unofficial residents and transients include squirrels, thirteen-stripe ground squirrels, chipmunks, weasels, muskrats, opossums, foxes, and barn swallows which nest in the roof of the moose shelter. There even is

a misplaced Asian – a peahen which had the freedom of the zoo grounds but decided that the moose yard was not only a nice place to visit but also an excellent place to raise a family.

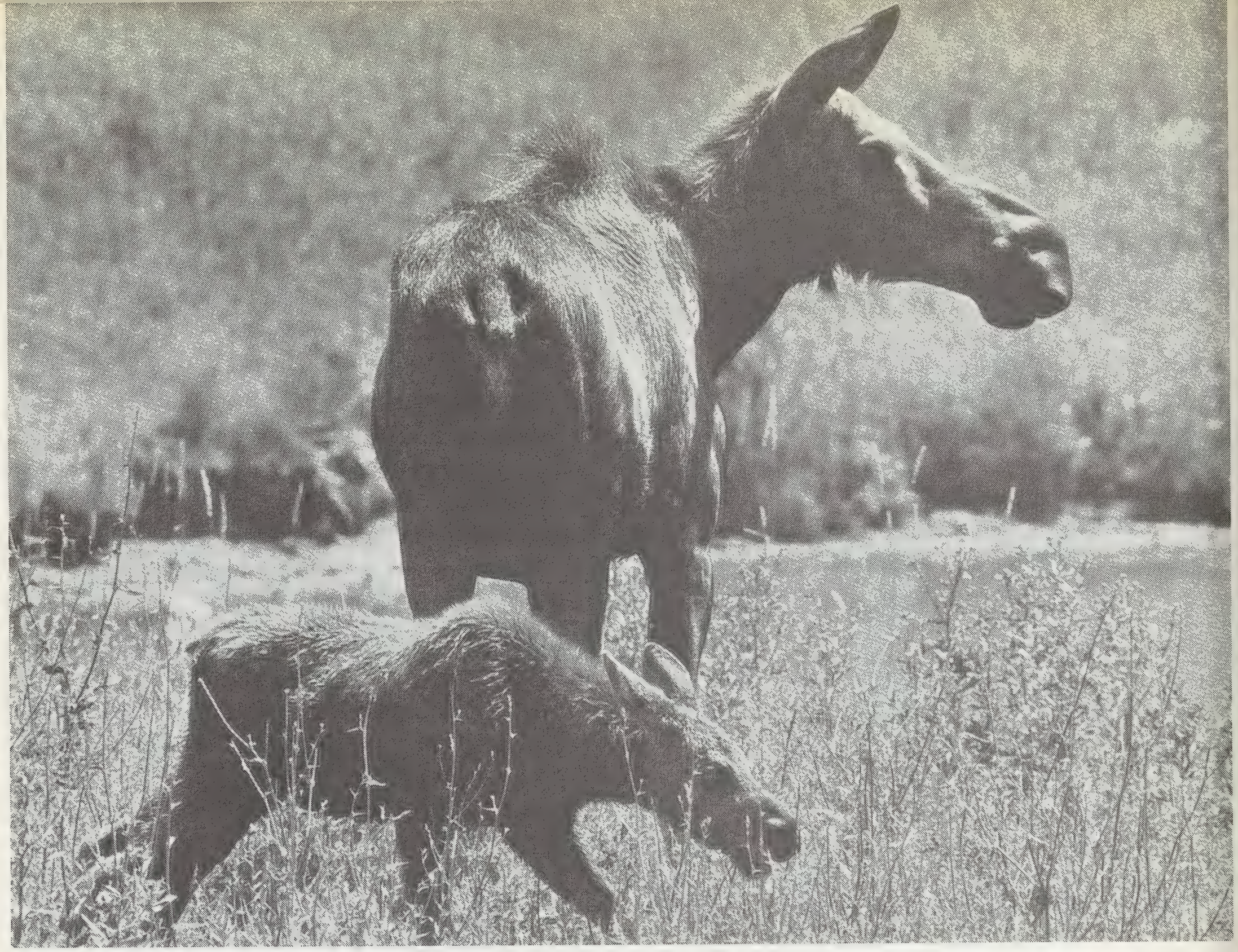
The mule deer previously had shared a smaller yard for a brief period with American elk, but those large animals harassed the mule deer. Moose are rather solitary creatures, indifferent to other deer, and even to their own kind – except for calves, of course, and mates during the rutting season. So they accepted the mule deer and when moose calves chase mule deer, it's all in fun.

The mule deer are confident. When they want a snack from the moose food bin, which is as high as the deer, they simply jump into the bin. They also eat some of the browse.

The mule deer and moose have produced young in the moose yard. Ducks and geese have nested on the banks of the moose's pond. At the suspicion of danger, a cow moose protecting calves lowers her head and puts her ears down and back. The whites of her eyes glisten, and if the offender – usually a curious sister moose or the placid bull – comes too close, the mother charges in a most determined fashion.

Mother moose does not chase off other residents of the moose yard – the frisky mule deer, the turkeys, or the geese. She does not consider them threats, so they are allowed to approach the calves.

Like other outdoor exhibits at the Milwaukee Zoo, the moose are in a prey-predator setting. They are separated by a hidden moat from



Alaskan brown bears, the largest living land carnivores. A big Alaskan bear and a large Alaskan bull moose weigh about the same – from 1,300 to 1,600 pounds. Alaskan moose are bigger than Canadian moose. Major is a full-blooded Alaskan, and that is the strain being bred into the Milwaukee herd.

Since May 1953, a total of 37 moose calves have been born at the Milwaukee Zoo. Eleven of the calves died, a mortality rate of 35.1 percent. In addition, there were four stillbirths.

Six Milwaukee moose were sold to other zoos – the Munich zoo and five zoos in the United States – and seven were shipped to Smokey Lake Reserve, a 6,000-acre private game preserve near Phelps in northern Wisconsin.

The reserve is owned and managed by P. C. Christiansen, a lumberman and the founder of the Moose Breeders and Exhibitors Corporation, an organization devoted to the breeding, preservation, protection, and exhibition of moose and other species of Wisconsin animals. Mr. Speidel is a director of the organization.

Duke, the moose, was released in the Smokey Lake Reserve – appropriately, near Moose Lake – in the hope that by returning him to the forest, where he would have to roam for browse, he

would fully recover from a fall he had taken in the Milwaukee moose yard. He had injured a leg when he slipped on ice in January 1968. The leg remained stiff, so that more than a year later, he continued to walk with a slight limp.

Duke was a calf when he arrived at the Milwaukee Zoo on October 16, 1959. He received special care from keepers, especially from Odean "Duke" Schneider for whom he was named. At Smokey Lake Reserve, he reverted to the wild immediately. He was seldom seen and, at the approach of man, he soon vanished, drifting back into the dense woods like a ghost. Mr. Speidel and his wife spent a week's vacation at the reserve in August 1969, four months after Duke was released there. Late one afternoon, they saw him near the side of a road.

Duke was nibbling on a bit of maple and he did not seem to notice the Speidels in their car. If he did, he ignored them. In a minute or two, he wandered off, still nibbling.

And that has been Duke's way ever since. Mr. Christiansen and his men catch only glimpses of the big bull. They say he looks well. Duke is a Canadian moose. So was Vitamin, the first moose born at the Milwaukee Zoo – on May 7, 1953. Vitamin had been sickly since birth. She seemed to have a vitamin deficiency – thus the name – and her left rear leg was crippled. The leg broke when she was about eight months old, but after weeks in a sling, it mended. However, she continued to limp and in July 1955, Mr. Speidel decided to transfer her from the one-and-one-half acre moose yard at the old Washington Park Zoo in the center of Milwaukee to 120 acres of fenced-in woods on the city's west side. It was hoped that her condition would improve in these woods. She could browse for miles, as she would in the wild, with a chance to use her moose instinct to concoct a menu that might restore her health.

The ailing moose's new home – the 120 acres – was a major portion of the site of the new Milwaukee Zoo. Thus, Vitamin became the first zoo animal at the new zoo. In fact, she was there years before the zoo itself was. Construction of the first building, the primate house, was not to begin for another three years.

Vitamin shared her new home with oldtimers – foxes, opossums, raccoons, skunks, squirrels, birds, and other small woodland creatures. There also were a few men around – workmen laying pipes or preparing experimental zoo rockwork. The men saw the moose occasionally, but she did not seek them out. She shunned them in true moose

fashion. Although she once had enjoyed the friendship of men, she became a wild creature at once, as Duke was to do 14 years later.

Since there was a hydrant in the area where the primate house was to be built, it was easy to provide Vitamin with a large tank of fresh water. Keepers also left food – sliced apples, bananas, bread, and mangels – near the tank to supplement her browse diet.

Each day, keepers looked for her, and they usually found her, or at least caught a glimpse of her. They saw that she still limped, but they also noted that she had gained weight and her coat was thick and glossy. A newspaper photographer took

a picture of her, nibbling on a branch. She looked bulky, sleek, and healthy.

Then, one day late in September 1956, Vitamin was missing. She was never seen alive again. About two weeks later, her carcass was found. It had been partly devoured by animals of the woods. The cause of death was not determined. Now, where Vitamin once wandered alone, there are grounds for elephants and lions, and the woodsy moose sanctuary. This yard – this reflection of the wild in the city – is near two contrasting products of man, an artificial lake and a freeway.

The lake, which is bordered by fir trees, willows, and maples, looks wilder every year. So does the freeway. Migrating wild ducks and geese stop off at the lake as well as the moose yard pond. The freeway hums.

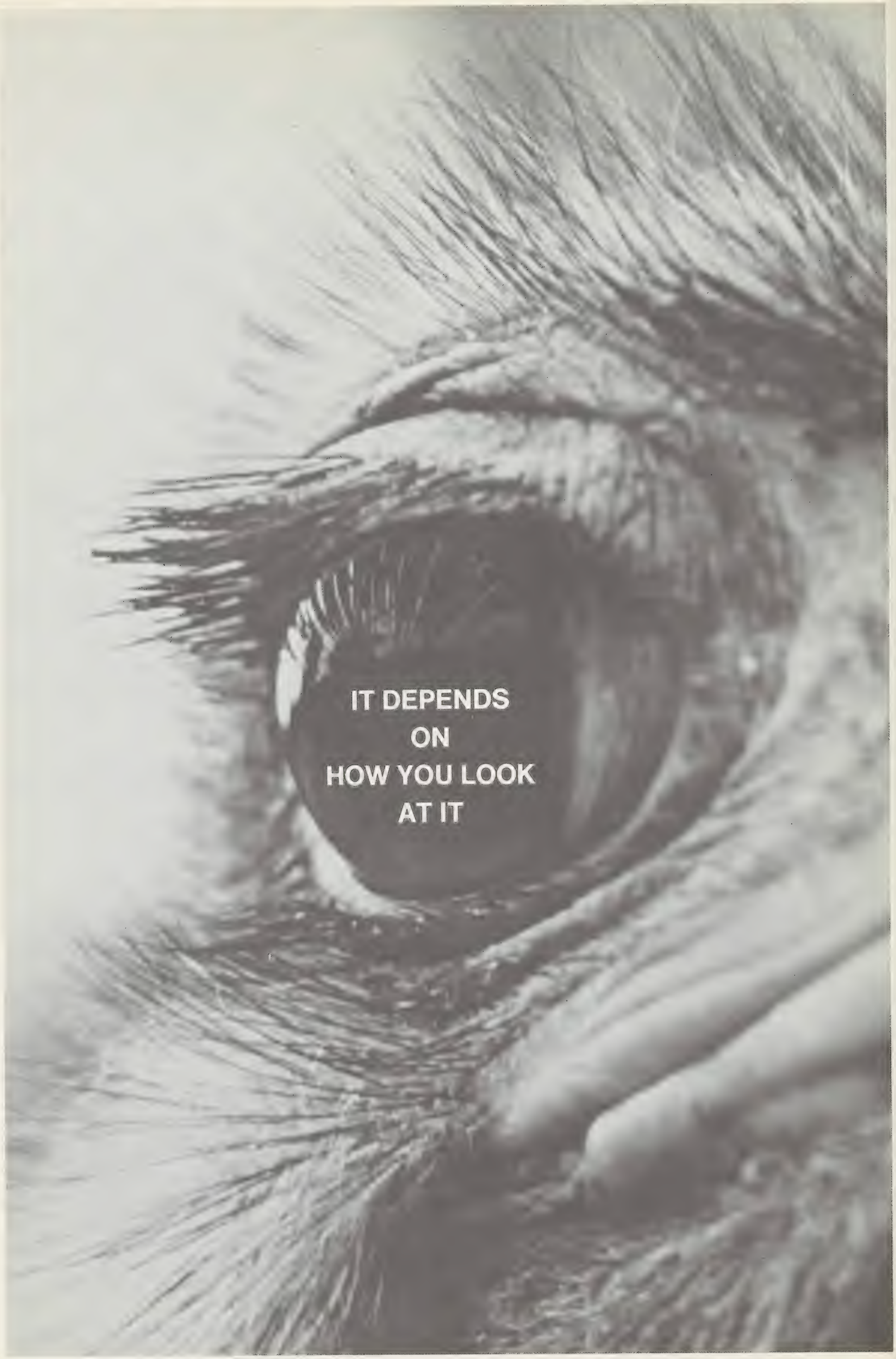
Zoo visitors who skirt the lake to arrive at the moose yard forget the freeway. They screen out its hum – that whosh that is like the surge of a crystal stream. It is constant – louder at times, but constant, so that it remains in the background, never intruding.

On a hot August day, twin moose calves wade in the pond. The big bull relaxes in the shade. On a crisp September day, the calves romp after mule deer or chase turkeys. Visitors can almost watch the calves grow as well as run. The little moose gain several pounds a day during their first weeks, and they continue to grow rapidly until they reach adulthood.

In October, as the red and yellow leaves begin to drift from the trees, the huge bull moose struts through the yard. It is the rutting season, and once again he is the symbol of power and virility. He is transformed totally into an unconscious, explosive force – dominating, like nature herself.

In such overwhelming tension, he moves stiff-legged, head-lowered, antlers swaying from side to side. In the summer, the bull had been docile, easy to approach. Now, in the fall, he is one of the most dangerous animals in the zoo. His good friends, the keepers, do not go into the yard, for he would kill them.

Mr. Speidel's home is on the zoo grounds, and at dusk, after the zoo closes, he often visits the moose yard. As the sun fades, the pond turns silvery. Ducks cruise in, splitting the water. A doe mule deer bounds from a shadow. The bull moose turns his head toward the freeway. The cars are only 200 yards from him, but he is many miles and many centuries away from them.


IT DEPENDS
ON
HOW YOU LOOK
AT IT

VISION IN THE ANIMAL WORLD

by Edward Edelson

An eye is an eye is an eye – or is it? While all animals have eyes with which to see the world, what they see and the way that they see it vary so widely that their worlds seem wildly different.

A fish, for example, lives in a visual world whose horizon is only a few yards away, with a sky that is a porthole of light. An insect lives in a world of crudely made mosaics, where many objects glow in dark colors invisible to man. For many mammals, the world is colorless. But for birds, it is full of fantastically detailed sights that man can only begin to imagine. A hawk can spot a mouse from the top of the Empire State Building.

Underlying this remarkable diversity of visual worlds is an equally remarkable diversity in the organs of sight. "The variety of photoreceptors among animals is almost incredible," says George Gaylord Simpson, the noted student of evolution. "Given the properties of animal cells and tissues in general, it seems nearly impossible to think of a practical means of photoreception that has not appeared in one group or another."

In its simplest form, the eye is not an eye. It is a light-sensitive cell that enables simple creatures such as the earthworm to distinguish light from darkness. Even one-celled animals – protozoans – have this light sensitivity, and it can be found much higher in the evolutionary scale; some lizards change their skin color in response to light, and they retain this ability even when their eyes are put out of action temporarily.

But any higher animal needs a more complicated structure. To find food (and to avoid being found as food), an animal must detect shapes and movement. It needs an image-forming eye.

The basic design of such eyes is roughly the same in all animals. A clear lens admits and focuses light. The light falls on other cells which transform the light into nerve impulses. These impulses are then interpreted by the brain to create a picture of the world.

Nature is in a sense thrifty, and image-forming eyes are built from the elements of simpler eyes. In insects, for example, some larvae have simple eyes consisting of dark-pigmented cells surrounding the photosensitive cells. Such an eye is called a "lateral ocellus." To make a more complicated eye, simply add more ocelli. Tiger beetle larvae have six lateral ocelli. Two of them are giants which contain more than 6,000 photosensitive cells.

The basic plan of the ocellus suits insects that need a better picture of the world, but the elements of the eye are elongated and packed together in great numbers to form a compound eye. Each element is called an ommatidium, and it consists of a tiny lens that focuses light on the light-sensitive cells that together make up the insect's retina. While each lens is capable of forming a tiny image of the world, the insect does not see a myriad of such pictures, scientists believe. Since 1829, they have accepted the theory put forward by entomologist Johannes Muller: insects see a mosaic made up of tiny spots of light, one spot per ommatidium.

To get a rough idea of what an insect sees, peer at the world through a handful of tightly-packed drinking straws with thick walls. While this eye is incapable of showing much fine detail, it is excellent at detecting movement – and movement is crucial to an insect trying to avoid predators. The number of ommatidia in the eye determines how much detail the insect sees. While a housefly has 4,000 elements in its eye, large dragonflies may have as many as 28,000. The dragonfly is a hunter and needs finer detail than a housefly, which is the hunted.

But man cannot really appreciate the world that the insect sees, because he does not see the colors seen by insects. Man sees the spectrum from deep red through to purple. Insects are not able to see red, but they can see ultraviolet rays invisible to humans. This can make a dramatic difference, as some scientists at Cornell University demonstrated. They outfitted a television camera with a lens that transmits ultraviolet light, then recorded its images on the camera's monitor screen.

"To the uninitiated, the first ultraviolet view of a meadow in mixed bloom is unforgettable," they reported in the journal *Science*. "Evenly-tinted flowers, which to the naked eye appear to lack the usual central or radial color markings that direct an alighted pollinator to its goal, are suddenly revealed to possess such markings in the ultraviolet. Other flowers, visibly patterned, are additionally adorned in the ultraviolet. Flowers that appear similar to us . . . may in the ultraviolet be grossly dissimilar . . ."

In shooting down insects with jets of water, the archerfish at the New York Aquarium have to compensate for refraction (above). Birds of prey, such as the red-tailed hawk (opposite), have keen vision.

Butterflies and other insects also look sharply different in the ultraviolet, the Cornell scientists found. Some have two visual patterns, one in the colors visible to predator birds, the other in the ultraviolet hue that attracts members of their own species for mating.

Insects have one other visual ability that is strange to man. They can detect polarized light. Light consists of waves that ordinarily vibrate in a disorganized manner in all directions. If something makes those waves vibrate in the same direction, the light is said to be polarized. Scientists have found that light coming from a blue sky is polarized; man cannot detect the pattern but bees can, and this helps them navigate. No one knows how insects detect polarization, but it seems to be a quality built into the cells of the retina.

Like most other features of an insect, its eyes are so alien to man that he can hardly relate to them. Most higher animals have eyes that are basically similar to man's: a lens that changes shape to focus light on the light-sensitive cells of the retina. Almost always, there are two kinds of cells in the retina: cones, which are primarily concerned with color vision, and rods, which are better in low light intensity but cannot detect color. The eye has an iris that widens or shrinks to let in more or less light, depending on intensity.

The fish varies most from this plan, because of the nature of the medium in which it lives. First, the fish does not have an iris; since the intensity of light in water is never high, there is little sense in having a mechanism to protect the eye from too much light.

Second, the fish's lens is almost spherical. This is because the len's focusing power depends on refraction – the bending of light waves as they pass from one medium to another. There is much less refraction when light passes from water to the eye than when it passes from air to the eye, and so the fish's lens must be nearly spherical to focus light at all.

Third, a fish does not have to worry about seeing far ahead, since there is not much chance of seeing very far in water. By man's standards, fish are terribly near-sighted.

Fourth, fish must adjust to the fact that, at a certain angle, light passing from air to water is reflected back. This means that a fish's sky is bounded by this angle of reflection. As the fish darts close to the surface, its sky narrows; as it dives deeper, the circle of light overhead broadens.

If this is not unusual enough, consider the problem of the fish trying to see from water into the air. A human sees an oar appear to bend at the waterline because of refraction, and a fish must see

the same thing in reverse. That means some unusual adaptions. The anableps, a small river fish of Latin America, has what amounts to two sets of eyes. The anableps can swim with half of its eyes out of the water; the upper halves are adapted to vision in air, the lower halves to vision in water. The archerfish, which gets its food by shooting down flying insects with jets of water, manages to hit the target even though it must compensate for refraction.

One final complication: most fishes really get two views of the world, one from each eye. In humans, the eyes look straight ahead, and the nerve cells from each eye split up, so that both sides of the brain receive the same image. In a typical fish, the eyes look out sidewards, with little overlap in their fields of view, and all the nerve cells from one eye go to one side of the brain. Somehow, the fish manges to put those two images together to form a coherent picture of the world.

When it comes to birds, the picture is simpler: they see the same way that man does, only better. Because life in the air relies so much on vision, the bird's eye is better in almost every respect than man's. Focusing is one example. A chicken can change focus almost instantly from a kernel of corn on the ground to a hawk high overhead, because it can change the shape of its lens more drastically than can man.

Sheer size is another example. In the case of the owl, the eye occupies as much space as the brain, while the ostrich's eyeball is two inches across. Even in less extreme cases, a bird's eye seems disproportionately large. If a man had eyes on the same scale, they would weigh five pounds, one expert estimates.

In addition, the bird's eye usually is packed with more visual cells. In man, the most sensitive part of the retina, the fovea, has about 200,000 visual cells. A hawk can have as many as 1.5 million cells in the fovea – and some birds have more than one fovea. For all practical purposes, the sparrow hawk looks at the world through eyes that are the human equivalent of eight-power telescopes.

The bird's eye has one feature that remains a mystery: a conical section, jutting toward the lens, called the pecten. Over 30 theories have been proposed to explain the function of the pecten, but none of them has been proven. The most widely accepted theory is that the pecten, which is heavily supplied by small blood vessels, somehow supplies the eye with nourishment.

Placement of the eyes gives many birds another advantage over man. The narrow, pointed shape of some birds' heads makes it possible for them to focus on objects both in front and behind them. A woodcock actually has better binocular vision of some objects behind it than in front of it, while a pigeon's field of view covers about 340 degrees. An owl, on the other hand, has its eyes facing forward in a flat face, which makes it (like man) unable to see much to the sides. To compensate, the owl has neck muscles that allow it to turn its head almost in a complete circle.

And being a night hunter, the owl has another ability. It can detect objects in only one-hundreth the illumination needed by man. This ability is so impressive that scientists have wondered whether owls can detect prey by zeroing in on infrared radiation given off by animals. But tests failed to show any signs of this, indicating that the owl's night vision is truly remarkable.

Rather than marveling at the vision of birds in comparison to that of man, fishes, and insects, scientists point out that every species has been equipped by the long, slow process of evolution with the visual apparatus it needs to survive. In a very real sense, all animals' eyes are both remarkable and prosaic; they are examples of evolution in action.

A DAY WITH NUMBER 19

REPORT ON A STUDY OF THE KOMODO MONITOR

by WALTER AUFFENBERG

Dr. Walter Auffenberg returned this summer from Indonesia where he spent a year studying the giant monitors on Komodo Island with his wife and three of their four sons. This study was made possible by a grant from the Conservation Fund of the New York Zoological Society.

Komodo in August is dry and forbidding. It is the height of the dry season and no rain will fall until the end of December. The dry season begins in March and is heralded by floral quiesence and death, which follows on the heels of the last drops of rain. First, grasses begin to die. By July the leaflets of the tamarind trees are falling in a soft, rusty shower. The heat of August shrivels the last bits of greenery and the island grays and withers. Surface temperatures in the sun reach 167° F. in the middle of the day, and a layer of powdery, gray volcanic ash is churned into miniature dust storms by small bands of deer and hogs seeking water. Under these conditions, my family and I began our year-long study of the giant monitors of Komodo, or "ora," as they are called by the Komodo islanders.

During the year we obtained considerable data on the size, density, and distribution of the monitor populations on Komodo and the adjacent island of Padar. We also studied the lizards' feeding habits, social relations, and cyclic activity patterns. It will take at least another year to analyze the information we gathered, but even now certain conclusions can be drawn regarding the usual daily activity pattern of the larger lizards in the population. Two rather usual behavioral features dominated this pattern: the search for food and for shelter.

Much of what has been written about the feeding behavior of the Komodo monitor has been based on short visits to the island during which the animals were observed and photographed over carrion bait. Many authors believed this scavenging was the typical feeding pattern; others believed the lizards sometimes successfully attacked live prey as large as deer. We found that the Komodo monitor is both a scavenger and a fierce predator, at times capable of bringing down an animal as large as a half-ton water buffalo.

The individual reptiles that we observed for prolonged periods were assigned numbers for convenience. Number 19 was the largest *Varanus komodoensis* that we tagged, measured, and weighed in our research area. Our first encounter with this big monitor occurred October 12, 1969, when he entered the large stockade trap we had constructed. By the time we left the island at the end of May 1970, his whereabouts and movements on 80 different days were known to us. We knew this monitor better than any of the other 49 lizards that lived on our 4-square-mile observation area. We photographed him courting and fighting, and watched him hunting live prey and eating carrion. On one occasion we were able to follow him for six full days, plotting his movements and recording his every activity. We learned to anticipate his paths of travel and his behavior toward at least certain of the other large lizards in and near his activity range.

Number 19 was a full-grown adult, the dominant male of the entire east side of the Liang Valley, and probably the sire of hundreds of skittering young. In October he weighed approximately 85 pounds, and was 8½ feet long. By the end of May, he had grown to nearly 9 feet and his weight had increased to approximately 105 pounds. He could pull a 300-pound deer to the ground and swallow the entire head of a dead wild boar. He was a powerful despot who never became accustomed to our intrusions on his daily patterns.

The major topographic feature of his activity range was a small, grassy hill 250 feet high and about a half-mile from our camp, which was to the south. A narrow strip of tropical deciduous forest fringed the bottom of the hill, and from the top our entire study area was visible. Nearby was Loho Liang, the largest valley on the island, approximately one-and-a-half miles wide and two miles long. On the opposite side of the valley, the land rose in a series of grass-covered spurs and hills to connect with the central ridge of the island. This ridge, continuing in an arc to the north and then southeast back to the beach, constituted the extreme outer boundaries of our study area, a basin of four square miles.

Number 19 often spent the evening on the hill under a small clump of shrubs just inside the forest edge. He had scraped away all surface debris from an area about six feet long by two feet wide in a small thicket, and here he would rest.

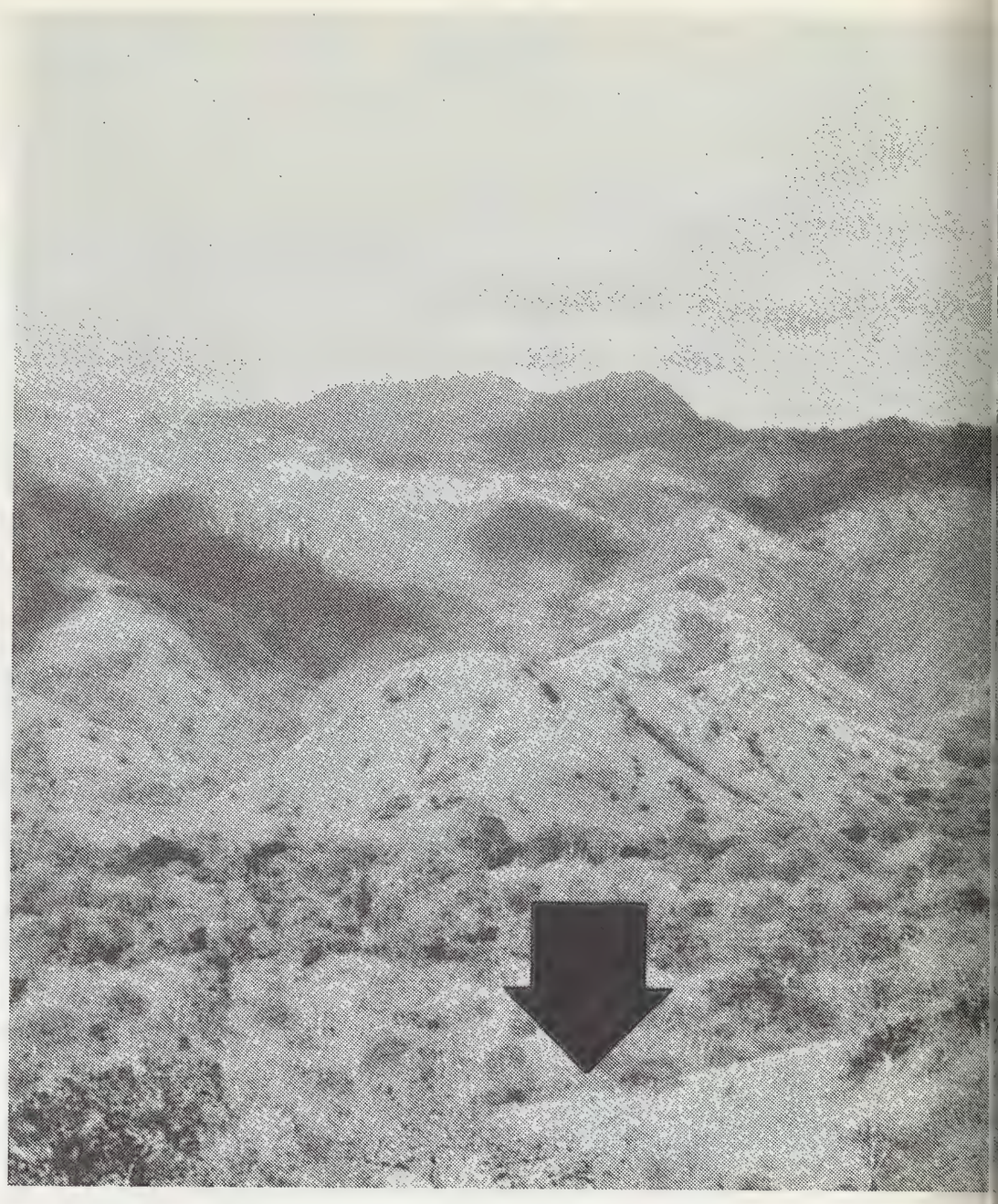
The afternoon air temperatures in the sun immediately in front of his resting spot were approximately 122° F. However, just under the

edge of the thicket it was shady and cool; temperatures there rarely rose above 79° F. The combination of the sun, shade, and wind patterns on the hillside caused this remarkably steep temperature gradient at the monitor's resting place. Therefore, it was very simple for 19 to regulate his body temperature very accurately by moving just a few feet in one or another direction. Like all Komodo monitors, 19 had several other resting spots of similar nature within one or two square miles. These retreats were always exposed to a good breeze and located immediately below a natural terrace on a spur leading to a higher elevation. The terraces often contained dense stands of *Themeda triandra* grass, four feet high, which were used as cover by deer, which usually arrived at the grass stands between 4 A.M. and 5 A.M. In late morning, as the temperatures on the open hillsides increased, the deer slowly moved – usually in groups of four or five animals in single file – into the forested base of the hillside along well-defined game trails.

By 6 A.M., as the sunlight started to spill over the crest of the ridge, the lizard usually could be found sprawled in the grass not far from the edge of the forest, with his eyes closed and chin resting on the ground. It took only a few hours for the sun to warm the dewly slopes, and by 8 A.M., 19 would enter the forest and creep along a trail which he had made, parallel to the open savanna. Two hundred feet down the trail was a place where 19 would lie and wait for prey along the game trail most frequently used by deer moving from the open hilltop into the forest below. For two or three hours, he would stay there underneath a fallen tree with his snout only about two feet from the edge of the trail.

Since this was not the only game trail leading to the valley, the chances were rather slim that 19 would be at the right trail at the right time to make a kill. If the deer came within the usual attack distance of three feet, 19 might lunge at one deer moving down the trail. If he was lucky, he would manage to clamp his jaws on some part of the deer – usually the hind leg above the hock, or often the throat in the case of a smaller animal.

An animal bitten in the leg frantically attempts to wrench itself loose. However, the monitor's tightly clamped jaws, curved teeth, and the powerful legs, which are propped against sudden jerks and twistings, resist the struggles of most deer. Even in the first few moments, the monitor's knife-like teeth can slice through several of the large blood vessels of the prey's lower leg.



Number 19 (pictured on page 18) was the dominant male Komodo monitor of the east side of the Liang Valley, which served as the focal point of Dr. Auffenberg's study. The arrow (above) shows the location of one of 19's major thermoregulatory areas at the ecotone between the valley forest and the hilltop savanna. Below, at left, a six-foot monitor waits in ambush along a hillside deer trail.

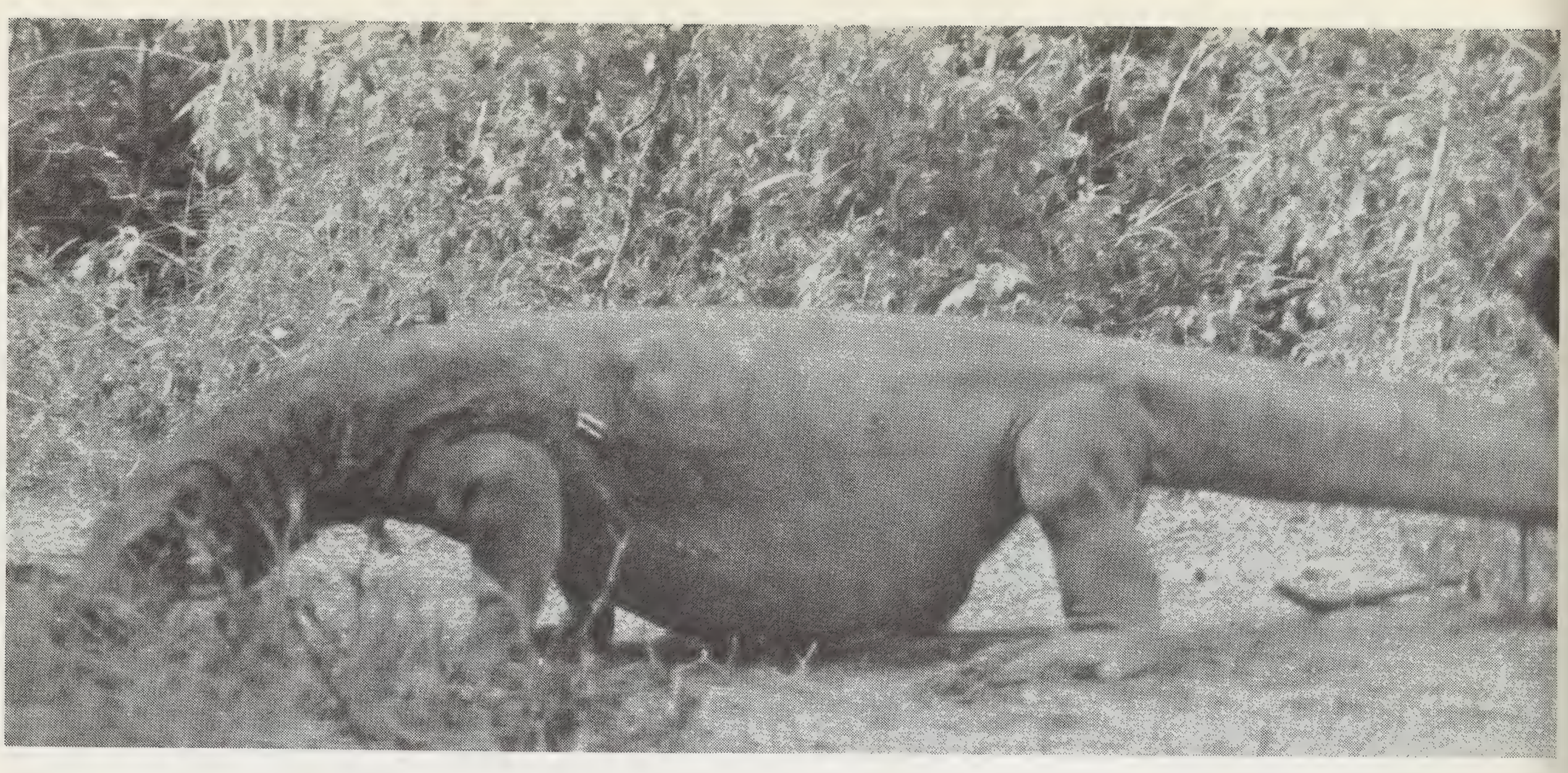
Even if an animal attacked by a monitor escapes, death still may await it. The bites of many monitor species, including the Komodo monitor, can transmit serious infection. The wounds from an attack by an ora often becomes septic, and cause massive infection that can weaken an animal. A deer in such condition is easy prey for another ora, if the deer does not die of the infection first. Dead, the deer is likely to be scavenged by other monitors. All of these facts amount to a form of protocooperation unexpected before the study was begun.

Number 19 was not always successful in bringing down prey. I suspect that he made a successful kill or discovered a reasonably large dead animal like a deer or hog only about once a month. Our big monitor could conceivably be more than a century old and must have experienced hundreds of hunts, unsuccessful as well as successful, in his range. This must have given 19 a thorough knowledge of the behavior of his preferred prey species, as well as of his own strengths and weaknesses and the physical characteristics of probably every square meter of his normal range.

Later in the day, 19 usually would head for a thick shrub area in which hogs and deer often slept under *Azima* and *Murrayia* bushes. Sometimes, however, the lizard would hunt for smaller game, such as rats and jungle fowl, in the more open sections of *Tamarindus* forest. On an average day he would probably seek both types of prey, and perhaps even stop at one of the large megapode bird nests, either to wait for the adult birds to alight, or to dig up the mound of earth in an attempt to find the eggs buried within.

Number 19 might find the droppings of other oras in game trails or on grassy hilltops, but on most days he would not see any other of his species. The density of lizards in this particular part of the island is approximately 25 animals per square mile. A majority of these lizards are from three to four-and-a-half feet long. When our monitor did come across other lizards, it was usually at carrion, where there is much interaction – such as courtship and breeding – between the creatures. Social heirarchies, based on size and weight, are often established and reinforced when the lizards gather to feed at carrion. At times small lizards are killed and eaten by larger ones.

Number 8 was another large male that lived in the same valley, but largely on the other side of a dry stream bed. When we came to Komodo in July, Number 8 was almost dead from starvation, and if 19 had found him at that time, he could easily have killed and eaten him. Quickly, however, 8 regained strength by feeding at the expedi-



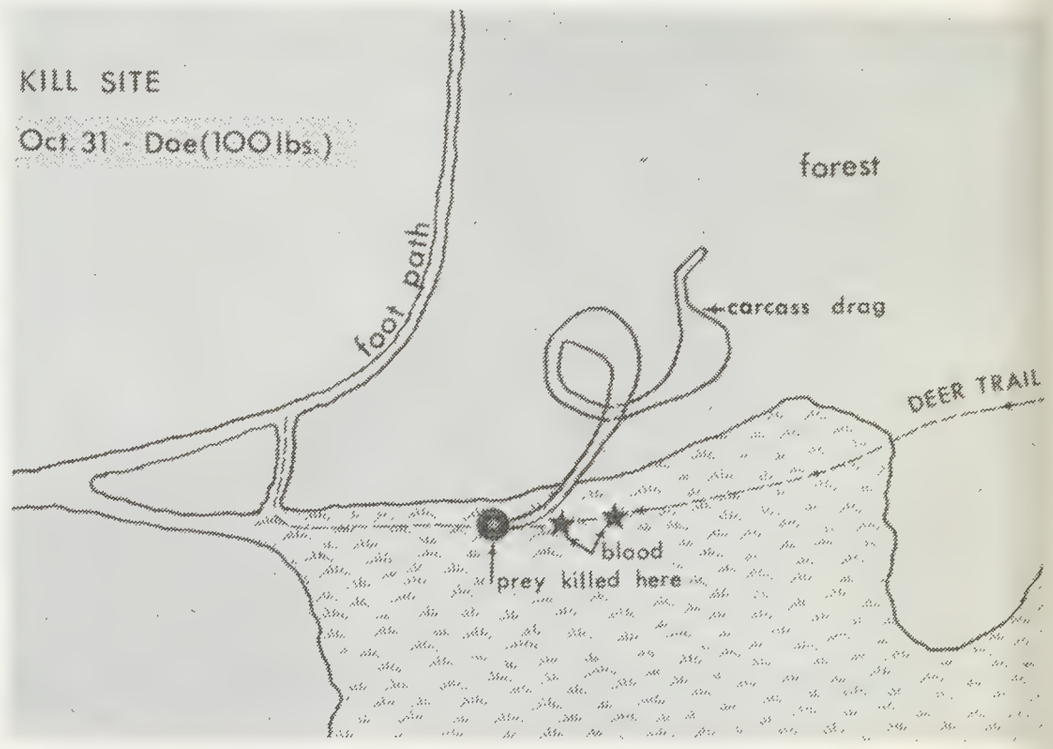
Number 23, a female measuring eight-and-one-half feet and weighing about 101 pounds, was photographed above just after eating all 90 pounds of a dead wild pig; except for a few wisps of hair, not one scrap of the carcass remained. Below are details of two deer kill sites in Loho Liang during 1969-70. A typical hillside burrow which Number 19 used for a few nights during late November 1969 is shown opposite.

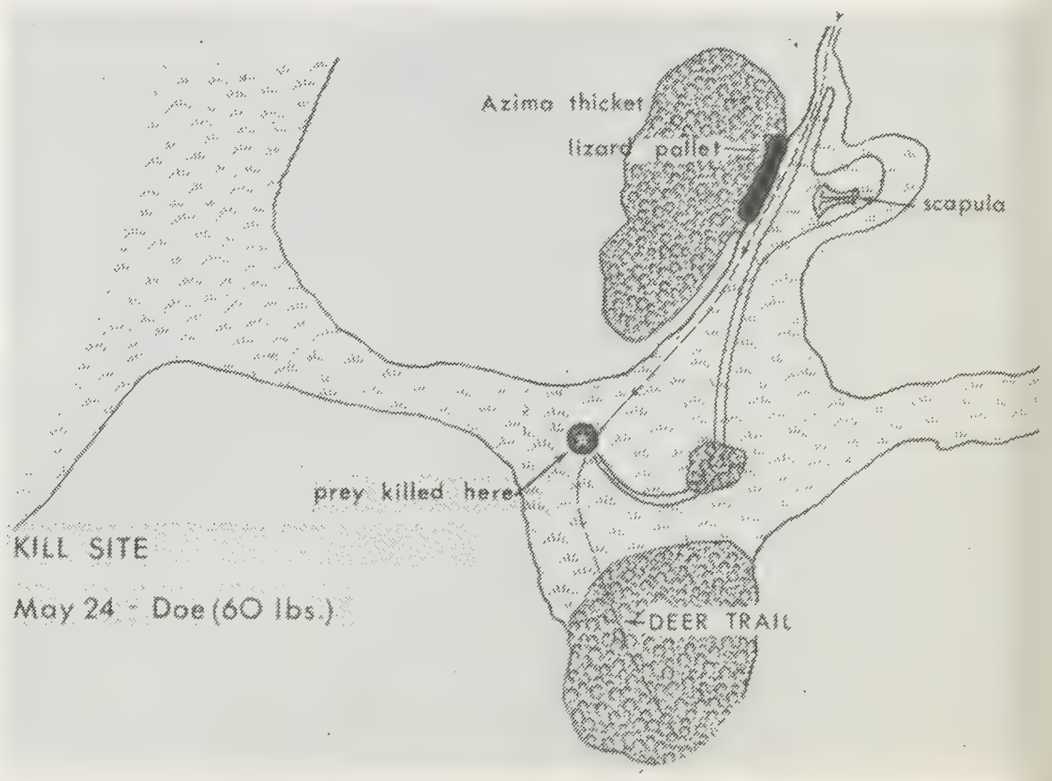
tion baiting site, and shortly thereafter he killed a hog and rapidly gained weight. However, on the few occasions when he and 19 had met at the baiting site, 19 dominated him, biting and chasing 8 whenever there was an opportunity to do so.

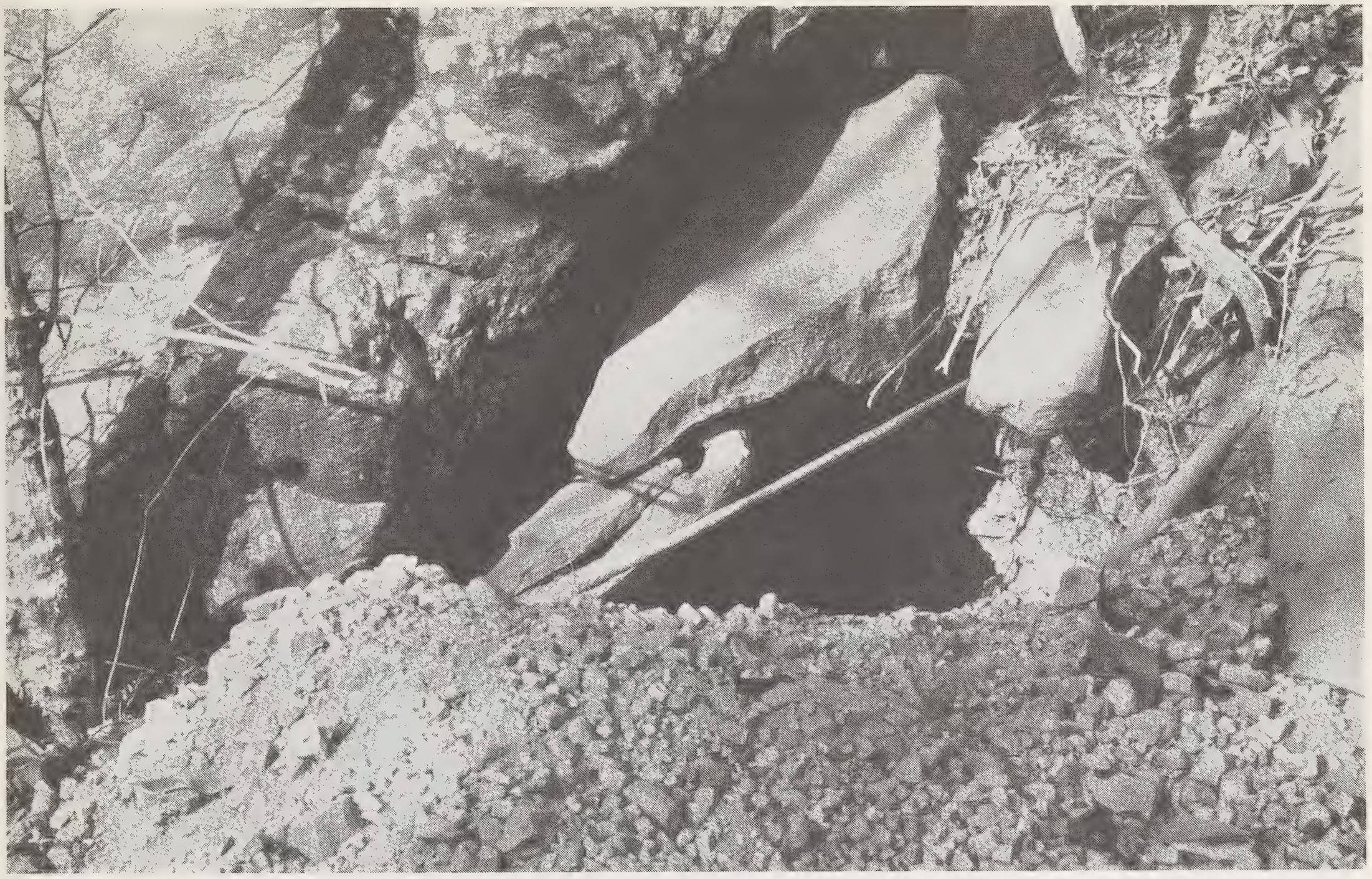
During his late afternoon hunt, 19 often entered a heavily overgrown garden plot, approximately a quarter-mile square, that had not been used by the villagers since 1965 when a nearby spring went dry. His tongue flicking the ground, the monitor would push through this tangle of brush, vines, and small trees. Through game paths branched in every conceivable direction, he took those leading straight to *Azima* bushes. He would usually stop within approximately 10 feet of each shrub and peer intently at the bush from 10 to 20 minutes. Then he would slowly slip under the protective canopy, sometimes to surprise a sleeping deer or hog. In this slow, deliberate fashion, the monitor would usually hunt no more than five to 10 *Azima* bushes an afternoon. Sometimes he would sleep under one of the bushes during the night, to resume the hunt the following day.

Just to the west of the overgrown garden was a large area composed mainly of several types of spreading shrubs and trees covered with tangled vines. Here the lizards also often attack and kill deer and hogs. A story related to me by three villagers provides a glimpse of typical ora hunting technique in this habitat.

A medium-size hog of approximately 40 pounds ventured within 50 feet in front of 19. Because hogs are quite inattentive while rooting in the leaves, the lizard was easily able to approach to within several feet. Without hesitation the monitor







lunged forward and upward, grasping the hog in the right rear thigh. The ora hung fast though the hog squealed and jumped forward, pivoted, and turned. However, in its struggles the hog inflicted two puncture wounds in the ora's left shoulder. Many oras are scarred from such encounters, and past experience has probably taught all the larger ones to avoid the violent sideward thrust of the hog's head.

Several times during the struggle the ora would yank back with all of his weight slicing great gashes into the muscles of the hog's already profusely bleeding thigh. Looking rather confused and perhaps in shock, the hog stopped struggling. With a sudden and powerful backward jerk, the ora brought the hog down on its left side. The lizard then suddenly bit into the hog's exposed belly, tearing out the intestines. The hog died very quickly. The attack had taken approximately eight minutes until the hog was dead – a time only slightly less efficient than the attacks of some largely predatory mammals.

The lizard consumed the hog by violently slinging the intestines from side to side, emptying them of their contents, and bolting them down as fast as possible. Next the monitor ate the heart, liver, and lungs. Only after all the innards were consumed did the monitor start to eat the muscular flesh of the legs and back. Within 15 minutes all that was left of the hog was a few patches of hair and a few scraps.

The scent of the intestinal contents often draws one or two small oras that may be hunting nearby. While observing 19, we found that when smaller oras are present at the feeding site, they often threaten 19, but usually keep approximately 12 feet distant, rapidly circling the bigger monitor and his prey. Flicking their tongues continuously over the ground, the smaller lizards search for small bits of flesh that might have been shaken loose as the prey was flung about by the larger ora.

Once he had finished eating, 19 would move slowly, with his belly now dragging along the ground, to a point of forest jutting into the savanna below his home hill. Here he would rest, panting in the shade to help rid himself of excess heat accumulated during that part of hunting and eating activity that took place in the sun. After a while he would waddle on to the savanna and a small water hole, where he would enter the water and drink deeply. A well-worn trail led from the pool across the hot savanna to the cool forest belt at the foot of the monitor's home hill. This is the route the monitor would follow after drinking. By 5:30 P. M., Number 19 would re-enter the security of his vine-covered thicket at the ecotome between the hillside savanna and the firest, there to spend the night.

THE WHITE-QUILLED BLACK BUSTARD

SUCCESSFUL BREEDING—AT LAST

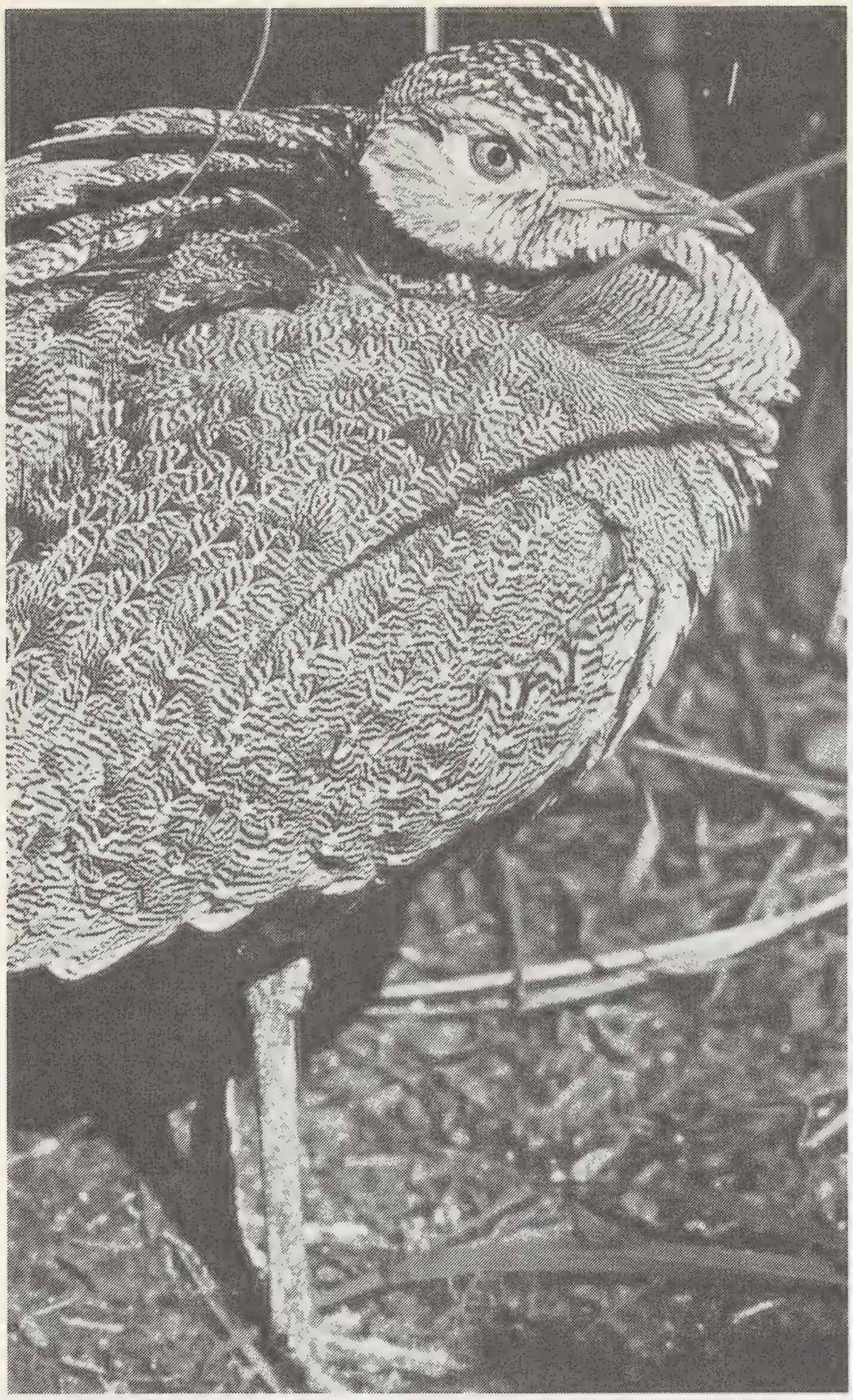
By Joseph Bell

Sometimes it seems as though telephones are ringing constantly in the offices of the bird department at the Bronx Zoo. Many of the calls are from people who are looking for information on the care of a cage bird or for help in identifying a wild one that they have seen outdoors. The remaining calls are mainly departmental communications dealing with the daily operations of the live bird collection.

The most exciting of those in the second category are usually from some member of the keeper staff and often prefaced with the question, "Guess who's nesting?" or "You'll never guess who laid an egg today!" The latter statement can have more than one meaning in the common usage of the day, but fortunately bird keepers are not generally facetious where such matters are concerned.

On the afternoon of February 4, 1969, the "guess who" question was posed by the keeper in charge of the Pheasant Aviary. The guessing game was cut short, however, by his eagerness to announce that he just had discovered a female white-quilled black bustard sitting on a nest containing two eggs. The bird was housed in one of the small winter shelters at the pheasantry, which she shared with two males and another female of the same species. Her nest was a simple scrape in the dry canestalk material used for cage flooring. When the hen bustard had been flushed from the nest, the heavily-spotted and streaked brownish eggs were almost invisible against this background.

Although a number of bustard chicks, hatched in the wild, have been reared in captivity, only three of the 23 species in the bustard family *(Otididae)* have ever reproduced successfully in a zoo or aviary: the little bustard in England, in 1910: the Houboura bustard, at Tel Aviv University, Israel, in 1961; and the great bustard, for the first time in 1964, at the West Berlin Zoo. Therefore, the nesting of a bustard at the Bronx Zoo's Pheasant Aviary was not only a rare event, but it also presented the possibility of a first captive breeding for this small South African member of the bustard group. A check on the



The coloration of the white-quilled black bustard is strongly dimorphic. The female (above, at left) is plain brown, while the male (above, at right, and page 24) is more strikingly marked. One of the successfully reared chicks is shown a few hours after hatching (page 27) and later when about 50 days old (page 29.)

nesting habits of this species revealed that the normal clutch was a single egg, rarely two.

The first decision to be made was whether to let the eggs remain in the nest or to remove them for artificial incubation. The small winter shelter was somewhat crowded but the three bustards sharing it with the nesting bird seemed indifferent to her. At least a few days of natural brooding might be beneficial – besides, we could find very little information about the temperature and humidity requirements for the proper development of a bustard embryo.

An early report on the day following the discovery was disheartening, but not wholly unexpected. One of the bustard eggs was missing and the other had a deep puncture. Examination showed that the punctured egg was infertile. We were disappointed, to say the least, but began a careful evaluation of the situation. Were these eggs the result of improper pairing of adult birds? It was almost impossible to guess, for the location and structure of the shelter allowed little opportunity for observation.

On one point there was no question: two of the bustards were males and the other two were females. Although visual sexual differences are subtle in some of the species of bustards, the white-quilled black bustard is strongly dimorphic in coloration. The male is a tawny-colored bird with a jet black head, neck, and underparts and patches of grayish white feathers on the crown, cheeks, lower neck, and leading edges of the wings. The female is a plain brown color and lacks the striking white patches of the male. In flight, or with wings dropped, both sexes show the marking for which this subspecies was named – the white inner webs of the black flight feathers.

While there was no question the sexes were paired properly, the rituals that might be involved for a successful courtship were another matter. Bustards are ground-dwelling birds. They live in open country, from grassy savannas and barren steppes to arid deserts. Although they are strong flyers, they prefer to walk rather than take wing

and even attempt to escape from danger by running rather than flying. Like many plains animals they are great wanderers, but only the northern species actually perform regular migrations. Omnivorous feeders, bustards eat almost every type of food, including small mammals, birds, reptiles, and even some vegetable matter, but their principal food is insects. In Africa, agriculturalists consider them as highly beneficial because of the great quantities of locusts that they consume.

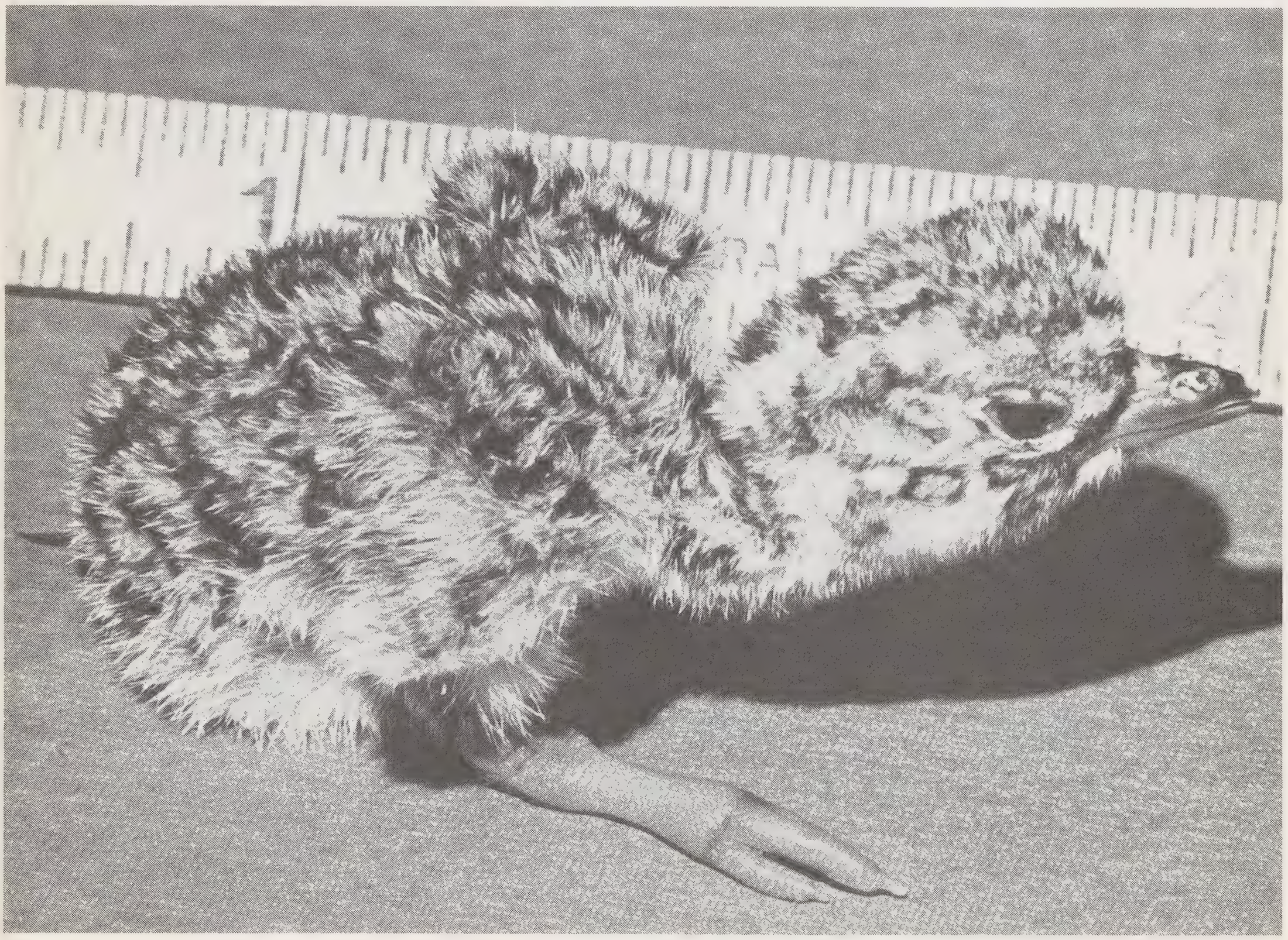
The courtship displays of the males include elaborate posturing, strutting, and even flight. On their breeding grounds, courting male white-quilled black bustards circle with slowly flapping wings about 50 feet above the ground. They call vigorously, then glide to the ground with feet outstretched. We thought that the lack of space at the Pheasant Aviary for this type of behavior might well be a clue to infertility.

When the bustard laid two more eggs in the shelter during March and another in early April, the eggs were removed for artificial incubation. Unfortunately, all were infertile. The advent of mild spring weather in the New York area allowed the opening of the shelter doors, giving the bustards the run of a large, heavily planted outdoor aviary. Although all four bustards had spent the winter months in apparent harmony, one of the males now looked much poorer than the other three birds and was retained in the shelter for special care.

Very little difference was noted in the behavior of the bustards at this time, but now the grating, often repeated *kr-aaak-a* call of the male could be heard easily several hundred yards away. These calls were well-known to the Boers who settled the South African region and earned this bird, along with several closely related species from that area, the name *knoraan,* or *knorhaan,* from the Dutch, meaning a "scolding cock."

On April 10, the hen bustard laid an egg in the outdoor aviary, but it too proved infertile, and hopes of ever achieving success became dimmer and dimmer. However, on the last day of May, the tawny-colored little hen again was found sitting very tightly on a single egg. The male, like all male bustards, took no part in the nesting procedure. By entering the aviary and approaching the nest, one might elicit his displeasure, and a harsh vocal comment, but that was all.

The hen bustard was permitted to tend this egg herself, but with so many past failures we had little hope of seeing a chick emerge. It was,



therefore, no great surprise when the egg was reported missing on June 20, and we adjusted to another failure. However, the next day it was noted that the hen was acting strangely; she was even more secretive than usual. The hint of a slight movement in the tall grass near her turned out to be the first bustard chick ever to be hatched at the Bronx Zoo. The youngster was about four inches of mottled tan and brown feathers, as difficult to see against the exhibit's background as the egg from which it came. Our excitement quickly turned to dismay, however, for the chick survived only one additional day.

Young bustards are bill-fed by the female parent for the first few days after hatching, and while our hen guarded her chick very closely, she apparently failed to give it any food. W. H. St.Quintin recorded a similar observation in the *Avicultural Magazine* in 1912: "I have more than once had young of the little bustard hatched but the chicks have never lived more than a few days owing to the nervousness and excitability of the mother, whose one idea was to draw the chicks away when attempts were made to supplement the failing supply of natural food in their enclosure."

While the loss of the first bustard chick was a real disappointment, it was heartening to know that there was a pair of breeding white-quilled black bustards at the Pheasant Aviary, not just a female bustard who laid eggs. When another chick was hatched September 20, it was taken from the female as soon as it was discovered and placed in a small heated brood-cage for hand-rearing. The chick weighed 21 grams at the time it was taken, but records of subsequent incubator-hatched chicks show that it probably had lost between 5 and 10 grams in the period before it was removed from the aviary. This is a fairly normal weight loss for a chick this size on the first day. The chick was hand-fed on a diet of diced meat, grubs, meal-worms, and chopped greens, reinforced with vita-mins and minerals, and it grew rapidly, actually doubling its weight in the first seven days. One of the real advantages in hand-rearing the chick in the restricted confines of a brood box was in knowing how much and what it ate. An interesting note by W. G. Percival, in an issue of the *Avicultural Magazine* for 1907, tells of his experience in trying to rear a bustard chick that he kept at liberty at his home. It is easy to understand why he became quite disturbed one day when he saw this young bird pick up and swallow a phonograph needle. The chick died several days later, and an examination of the stomach revealed "1 bootlace 19 1/4 inches long, 1 piece 13 inches, a fishhook 1/2 inch long, 2 gramaphone needles and a feather some 3 inches, also a 1/4 inch piece of wire. All this in addition to 2 pins that had worked out through the sides of the stomach."

Raised in the security of the brooder, the white-quilled black bustard chick did not have such a problem, but on the morning of its 67th day when it was full winged and nearing full size, it was found with severe fractures of one leg and one wing. Some sound or movement during the night must have startled the bird causing it to crash into the sides or top of its enclosure. The young bird never recovered from these injuries.

Real success with the white-quilled black bus-tard came only this year. One chick hatched in March 1970 and another in April. They were reared, banded, cataloged, and moved to a display area with a lack of incident that was almost anticlimactic.

Captive propagation of the type outlined here goes far beyond the prestige of a "first breeding" of a species. The bustards, like their near relatives the cranes, are facing rapid reduction and actual extinction throughout their range. The destruction of their natural habitat and excessive hunting are the major reasons for their decline. The northern species, which inhabit central Europe, Asia, Africa, and Australia, have been reduced to the point of rarity. Species now listed only as occasional migrants to the British Isles have been extinct there as breeders for more than 100 years. Although it has been protected by the Indian Government since 1952, the great Indian bustard is now so rare that the International Union for Conservation of Nature and Natural Resources places it on its list of endangered animals.

Bustards always have been regarded highly as game birds because of their size, highly palatable flesh, and the fact that their terrestrial habits made them relatively easy marks. In South Africa the group of small bustards known as knorhaans were once common items in the food markets of the larger towns. An interesting record for the Kim-berley market in 1906 shows that of the 40,933 items of game sold that year, 3,565 were knor-haans.

The real significance in the breeding of the white-quilled black bustard at the Bronx Zoo is in its contribution to the general knowledge of maintenance and propagation of the bustard group as a whole – the type of knowledge that might have helped to save the Carolina parakeet or the passenger pigeon from extinction.

animal kingdom REPORTS

Robert G. Goelet, President of the New York Zoological Society

Laurance S. Rockefeller, Chairman of the Board of Trustees

New York Zoological Society Elects New Officers

Robert G. Goelet, a New York conservationist and business executive, was elected president of the New York Zoological Society, succeeding Laurance S. Rockefeller, who became chairman of the board.

Mr. Goelet, who since 1968 has been the society's executive vice-president, has been a trustee of the society since 1951. Mr. Rockefeller, who served as president of the society for two years, has been a trustee since 1936.

The elections were announced after the annual meeting of the society's board of trustees.

Howard Phipps, Jr., secretary of the society, was named to the position of chairman of the executive committee, a post held for the past two years by Mr. Goelet, while George F. Baker, Jr., was elected a vice-president. Mr. Baker has been a trustee of the society since 1949. Mr. Phipps was elected to the society's board of trustees in 1961. Augustus G. Paine, II, was elected secretary. Mr. Paine has been a trustee since 1965.

Mr. Goelet is active in many cultural and conservation organizations. He is a trustee of the American Museum of Natural History, a trustee of the New York Historical Society, a director of the National Audubon Society, a member of the Cultural Council of New York City, and a director of the Caribbean Conservation Corporation.

Mr. Rockefeller has been a leader in the broad field of environmental quality, including conservation and outdoor recreation, and in philantropy and science-based industry. Among his activities and positions in these fields, Mr. Rockefeller is chairman of the President's Advisory Committee on Environmental Quality, chairman of the New York State Council of Parks and Outdoor Recreation, and a trustee of the New York State Historic Trust. He is also chairman of the Rockefeller Brothers Fund, chairman of the Memorial Sloan-Kettering Cancer Center, and president of the board of trustees of the National Board of the YWCA of the U.S.A.

ABOUT THE
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ILLUSTRATION CREDITS

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